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SMALL SCALE POULTRY PRODUCTION

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TABLE OF CONTENTS

	Page
INTRODUCTION	3
STRUCTURE OF THE CHICKEN	4
Nomenclature	4
Respiratory system	5
Skeleton	6
Digestive system	7
Urinary system	7
Reproductive system	8
Formation of the egg	9
BREEDS TO RAISE	11
STARTING A FLOCK	12
Incubation	13
BROODING CHICKS	16
Debeaking	21
GROWING PULLETS	23
HOUSING FOR LAYERS	23
ARTIFICIAL LIGHTS	32
CULLING	34
REPLACEMENT PROGRAM	36
Force molting	36
NUTRITION	37
Feed consumption of young chickens	43
Water	44
Formulating rations	46
Care of feed in storage	55
DISEASES AND PARASITES	57
External parasites	68
Internal parasites	69

MANAGING CHICKENS IN HOT WEATHER 72

EGGS FOR HOME USE OR MARKETING 75

Components of the egg 76
Care of eggs after they are laid 77
Candling eggs 80
Cleaning dirty eggs 82
Storing eggs 84
Diagnosing egg quality problems 86
Composition of the egg 89

PROCESSING POULTRY 89

REFERENCES 93

APPENDIX 95

SMALL SCALE POULTRY PRODUCTION

INTRODUCTION

Fresh eggs and poultry meat are nutritious because they contain large amounts of easily digestible, high-quality proteins, vitamins, and minerals. The chicken egg is considered to be a nearly perfect food for humans, lacking only vitamin C.

A family chicken operation is practical in many countries in the Pacific Ocean area. Raising chickens can be fun and will give training to the children. Depending on economic factors, chicken farming could become a small or large commercial enterprise.

No one should go into poultry farming blindly. You must have some basic knowledge of poultry breeding, nutrition and management. Chicken raising is not a matter of obtaining any type of chicken and feeding them leftovers from the kitchen or allowing them to forage for themselves. A hen of poor breeding will not lay many eggs no matter how well it is fed or cared for. A hen of good breeding will not perform well if nutrition and management are poor. Breeding, nutrition and management must all be favorable for an operation to be productive.

Before going into farming, ask yourself these important questions:

1. What commercial strains or breeds of chicks are available in the area and how much do they cost? Without knowledge of the principle of genetics and without adequate finances, no one should breed chickens.

2. Are commercially mixed feeds available? What are the prices? If feeds are not available, are feedstuffs suitable for chicken diets available?

3. What are the prices of eggs and chicken meat in the markets? Do you think you can produce them more cheaply than you can buy them?

Suppose the answers to these questions show that a poultry operation would be feasible. And suppose that you have little or no knowledge of poultry husbandry. How would you go about setting up a chicken enterprise? This publication was prepared as a guide for beginners who wish to raise chickens in small numbers. Included is information on larger scale operations, if you decide to expand. The material presented here is not complete, but an attempt has been made to cover the important points. Certain management practices depend on the climate and economic situation of the particular area; the practices described here are feasible under general conditions, and are based on the assumption that your operation is one of total confinement of the chickens. This means that the chickens will be totally dependent upon you for feed and water.

STRUCTURE OF THE CHICKEN

Structurally, birds are among the most highly specialized vertebrates. Their structure includes modifications or adaptations for flight. The basic structural systems of the chicken are as follows:

Nomenclature

The names of the parts of the male and the female chicken are shown in Figures 1 and 2. The differences between the sexes can be seen in the appearance of feathers in the neck, back, saddle, and the tail sections. These are some of the secondary sexual differences characteristic of birds, with some exceptions.

The feathers help protect the bird from physical injury and keep the

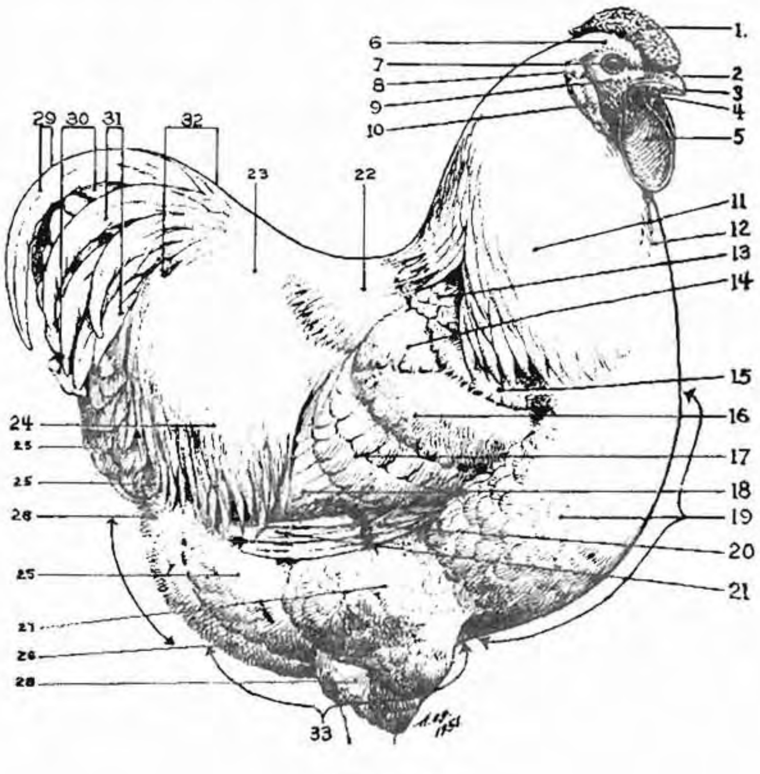


Figure 1.

NOMENCLATURE OF MALE

1. Comb
2. Upper Mandible or Beak
3. Lower Mandible or Beak
4. Throat
5. Wattle
6. Skull
7. Eye
8. Ear
9. Face
10. Ear-lobe
11. Hackle
12. Front of Neck Plumage
13. Cape
14. Shoulder
15. Wing Front
16. Wing Bow
17. Wing Coverts or Wing Bars
18. Secondaries or Wing Bay
19. Breast
20. Primary Coverts
21. Primaries
22. Back
23. Upper Saddle
24. Lower Saddle
25. Rear Body Feathers
26. Fluff or Stern
27. Lower Thigh Feathers
28. Hock Plumage
29. Main Sickles
30. Main Tail
31. Lesser Sickles
32. Tail Coverts
33. Abdomen

body warm. The wing feathers are, of course, necessary for flight.

Muscles

The muscular system of the bird is characterized by the special development of the large muscles of the breast. The greater part of the breast muscles appears to be on the body itself because of the extensive attachment to the sternum (Figure 3). These muscles weigh about as much as all the rest of the muscles together.

Respiratory System

The respiratory system of birds is quite different from that of mammals. The lungs are firmly attached to the thoracic wall, and the active part of respiration is exhaling. In mammals, the more vigorous part of breathing is inhaling.

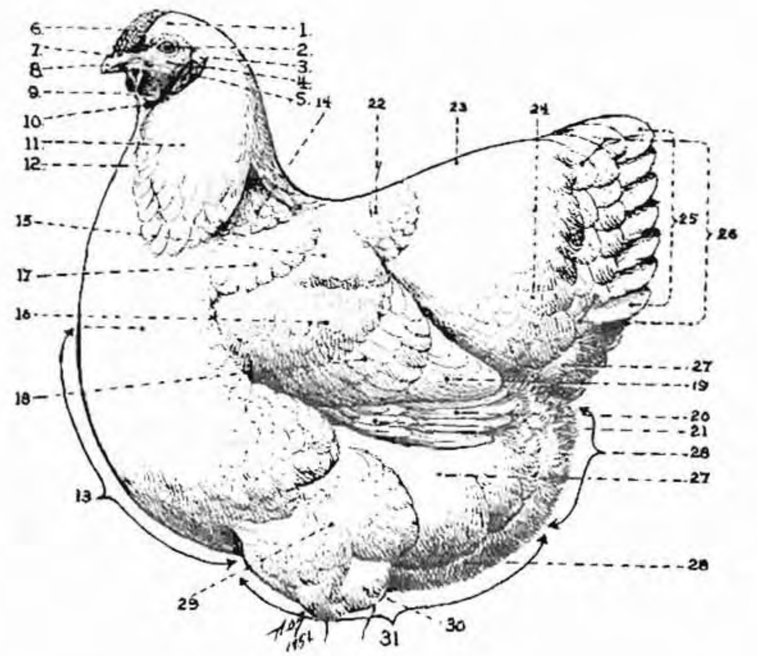


Figure 2.

NOMENCLATURE OF FEMALE

1. Skull
2. Eye
3. Ear
4. Face
5. Ear-lobe
6. Comb
7. Nostril
8. Beak
9. Wattle
10. Throat
11. Hackle
12. Front of Neck Plumage
13. Breast
14. Cape
15. Shoulder
16. Wing Bow
17. Wing Front
18. Wing Covert or Wing Bar
19. Secondaries or Wing Bay
20. Primaries
21. Primary Coverts
22. Back
23. Sweep of Back
24. Cushion
25. Main Tail
26. Tail Coverts
27. Rear Body Feathers
28. Fluff or Stern
29. Lower Thigh Plumage
30. Hock Plumage
31. Abdomen

Connected to the lungs are four pairs of air sacs located on both sides of the body. These sacs are found in the region from the neck to the abdomen. A single median sac is located in the cavity of the thorax. Besides opening into the lungs, the sacs are directly connected to the cavities of most of the bones of the body.

Skeleton

The skeleton of the bird is compact, lightweight, and very strong. Many bones are hollow; many are fused together, forming very strong structures to which the large muscles used in flight are attached. Figure 3 shows the skeletal system of the fowl.

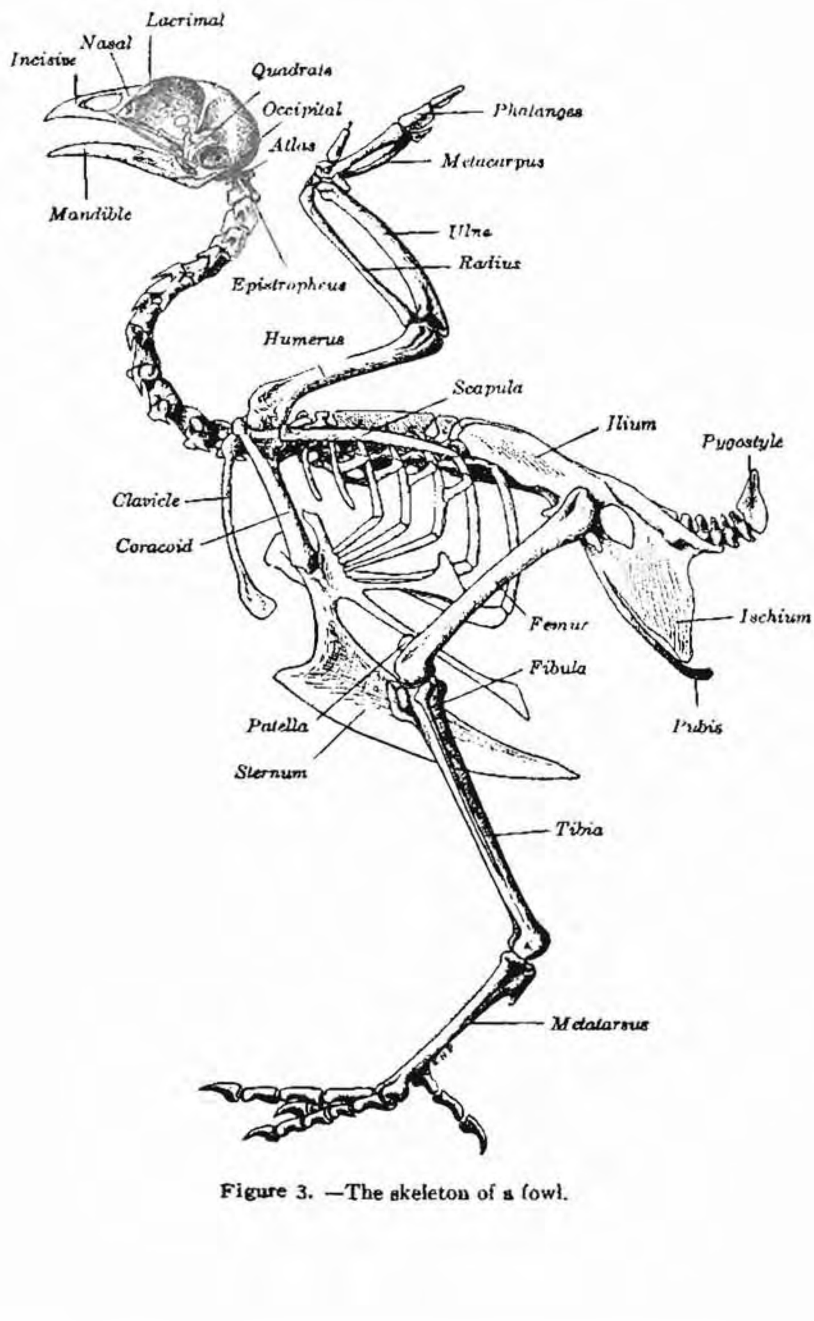


Figure 3. —The skeleton of a fowl.

Digestive System

Figure 4 shows the digestive system of the fowl. It is relatively short, a characteristic feature of meat-eating animals. Fowls do not have any teeth; instead, they have the horny mandibles that form the beak. Food is thoroughly pulverized in the gizzard, which corresponds to chewing in the herbivora or non-meat-eating animals.

At the juncture of the intestine and the rectum are two blind pouches called ceca. These are usually 4 to 6 inches long and more or less completely filled with fecal matter. Their function is not fully understood, though they seem to help in the digestion of fiber.

Urinary System

In the fowl, the urine is discharged into the cloaca and excreted along with the feces. No liquid urine is voided. The white, pasty material appearing in the droppings of birds is largely uric acid, whereas the

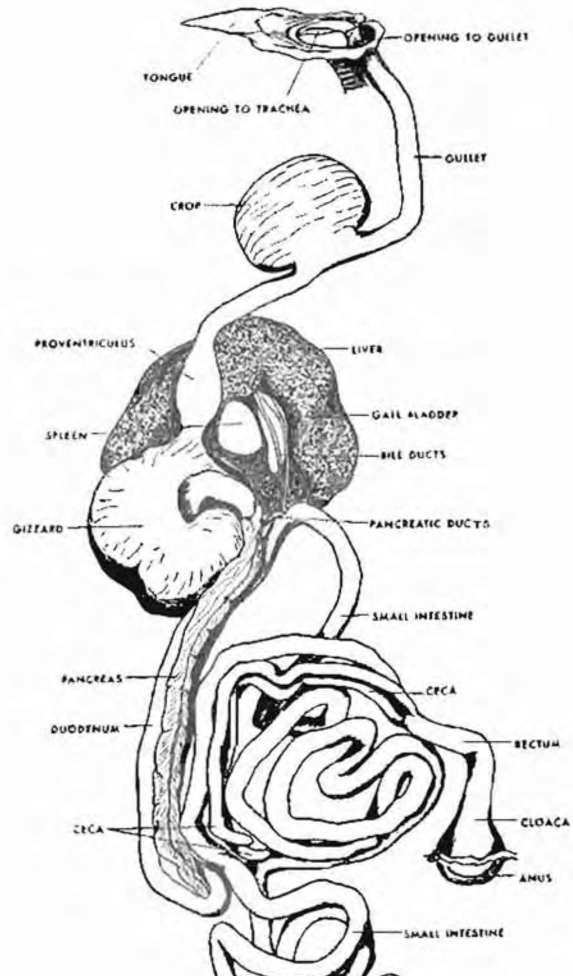


Figure 4. —The digestive system of the fowl.

nitrogen in the urine of mammals is mainly in the form of urea (Figure 5).

Reproductive System

The male fowl has two testes situated high in the abdominal cavity, along the back, near the forward end of the kidneys. These never descend into an external scrotum, as in the case of other farm animals. They are more or less ellipsoid in shape and are light yellow, frequently having a

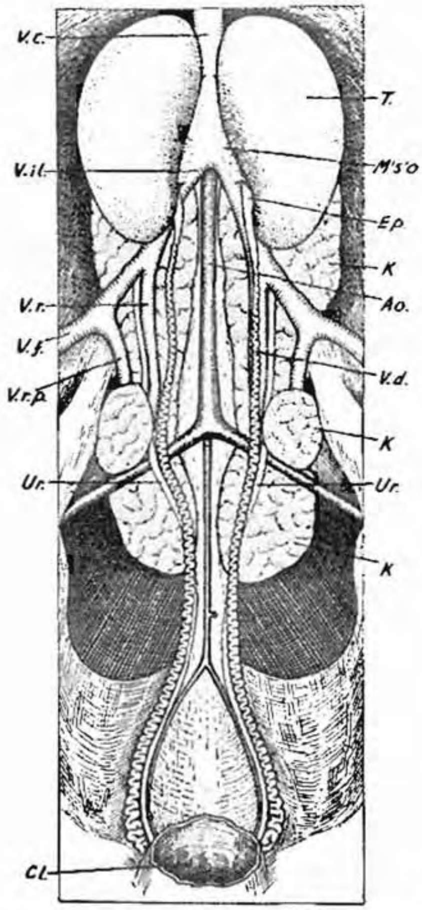


Figure 5. —The reproductive and urinary organs of the male fowl: *T.*, testis; *V.d.*, vas deferens; *K.*, kidney; *Ur.*, ureter; *Cl.*, cloaca.

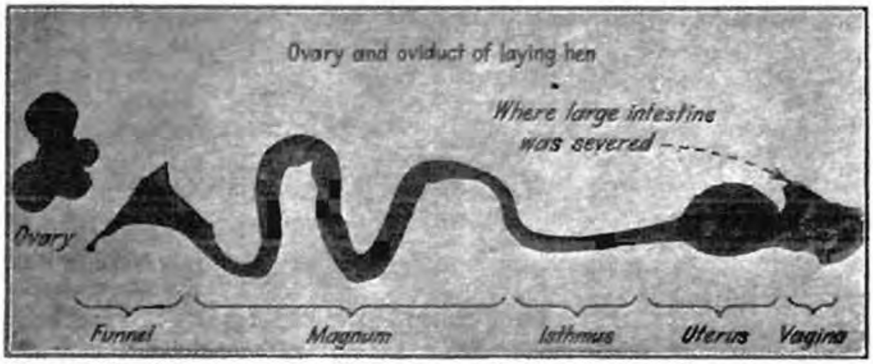


Figure 6. The left ovary and oviduct, with a fully formed egg in the uterus.

reddish cast caused by the numerous blood vessels on the surface.

The testis consists of a large number of very slender ducts. The sperms are given off the linings of these ducts, called the seminiferous tubules. They all lead eventually to the vas deferens, a tube which conducts the sperm outside the body (Figure 5).

Each vas deferens opens into a small papilla. Together these serve as an intromittent organ. They are located on the dorsal wall of the cloaca. The so-called rudimentary copulatory organ of the fowl has no connection with the vasa deferentia and is located on the median ventral portion of one of the transverse folds of the cloaca. It is this rudimentary organ, or male process, that is used in identifying the sex of baby chicks by cloacal examination.

The female usually has only one functional gonad. During the early stage of embryo development, there are two gonads, but only the left one finally develops. The right gonad, if present, is usually a nonfunctional rudiment.

The ovary is situated to the left of the median line of the body behind the lungs and at the forward end of the kidney. It is attached to the dorsal wall of the body cavity. In the inactive condition the ovary appears as a small, whitish mass of irregular shape. In the active condition it appears as a yellowing cluster of spheres of varying sizes. Each sphere is enclosed in a follicle. These spheres are ova, or reproductive cells of the female, and are commonly referred to as "yolks."

The oviduct is a large coiled tube (Figure 6) occupying a large part of the left half of the abdominal cavity in the laying hen. It is suspended from the dorsal body wall. The oviduct consists of six parts: (1) mouth, (2) funnel or infundibulum, (3) magnum, (4) isthmus, (5) uterus, and (6) vagina, which leads to the cloaca. At the anterior end of the oviduct is its mouth which is spread out beneath the ovary to receive the ova or yolks when they are ready to leave the ovary. The posterior end of the oviduct connects with the cloaca, from which the completed egg is expelled.

Formation of the Egg

Each yolk, enclosed in a follicle, is attached to the ovary by a very slender stalk. From the inner surface of this follicle, a thin membrane is secreted. This is the vitelline membrane containing the yolk material and the germinal disc.

Each yolk grows very slowly up to about 10 days before it is ready to leave the ovary. During the ninth and the eighth day before the yolk is ready to leave the ovary, growth is more rapid than previously. From about 7 to 4 days before the yolk leaves the ovary, the growth rate is very rapid, and for the remaining 3 days the rate of growth is relatively slower. Between 7 and 6 days before leaving the ovary, the yolk is only about one-tenth its mature size.

During the period of slow growth, only white yolk is added. During the period of rapid growth, when laying hens consume feed varying in xanthophyll (a yellow pigment) content at different periods of the day, concentric layers of white and yellow yolk are added. When laying hens are confined and regularly fed a uniform diet, the yolk added is uniform in color.

The yolk is released from the ovary through a break in the follicle called the "stigma" and is usually picked up by the mouth of the oviduct. If it is not, it falls into the body cavity of the hen, from which it is almost always picked up by the oviduct.

The parts of the egg formed in the oviduct include: (1) a layer of thick white, (2) the chalazae, (3) an inner layer of thin white, (4) an outer layer of thick white, (5) an outer layer of thin white, (6) two shell membranes, and (7) the shell. In breeds that lay brown-shell eggs, the pigment is added in the uterus. Table 1 shows the measurements of the parts of the oviduct and the approximate time spent by the developing egg in the different parts.

TABLE 1. Approximate length of different sections of the oviduct, approximate percent of albumen secreted in each of three sections, and approximate time spent by yolk in different sections

Section of oviduct	Approximate length Centi-meters	Approximate length Inches	Approximate percent of albumen secreted	Approximate time spent by yolk
Mouth	2.0	0.8		
Funnel	4.0	1.6		15 min.
Magnum	33.0	13.0	40 to 50	2 hr. 45 min.
Isthmus	10.0	3.9	10	1 hr. 15 min.
Uterus	12.0	4.7	40 to 50	20 hr. 45 min.
Vagina	5.0	1.9		

The data show that it takes an average of 25 hours for the hen to "form" the complete egg. The actual time varies with different hens, depending usually on the rate of lay. Some hens lay daily for several days before missing a day, whereas other hens lay an egg every other day or perhaps two eggs in daily sequence and then miss one day or more. The number of eggs laid on consecutive days is called a "clutch."

Among hens laying a few eggs in a clutch, ovulation usually takes place about 30 minutes after the previous egg has been laid. The act of laying is referred to as "oviposition."

Most eggs in a flock are laid between 8 a.m. and 2 p.m. Because of the time lapse between successive eggs in a clutch, laying generally occurs a little later each day until 2 p.m. is reached; then the interval usually extends into the following day before the next egg is laid. The 1-day interval between clutches is due to a postponement of ovulation. The laying of the first egg of the succeeding clutch is usually delayed about 15 to 20 hours.

The structure and composition of the egg is discussed in the section "Egg Quality and Preservation."

BREEDS TO RAISE

In most countries in the Pacific, native chickens or hybrids of native chickens and chickens brought in are raised primarily for meat. The majority of these birds are not confined and reproduce on the basis of natural selection. They also seek their own food or are fed limited table scraps from the family kitchen. As a result, it is likely that these chickens are small and lay very few eggs.

If you plan to start a chicken operation with the intent of obtaining maximum number of eggs per bird and high-quality meat, breeding should be controlled. The first thing to do is to decide on the breed of chicken to raise. The selection of the breed will depend upon the purpose of raising them. Is is for meat production? For egg production? For both meat and eggs?

Commercial hybrids for meat production show very economical gains in body weight up to 9 weeks of age. Beyond that age, however, these hybrids are not very economical--that is, their growth rate slows down while their feed consumption increases.

In most Pacific areas, there is not the demand for young (broiler and fryer) chickens that there is in the United States. If you plan to raise chickens for meat only, be sure you will be able to sell broilers and fryers in the markets or that your family will want the younger birds. If not, it would be better to consider a dual-purpose breed (see below).

For egg production, the Mediterranean breeds are desirable, particularly the White Leghorn (hybrids of different strains of White Leghorns developed by poultry breeders are also available). The Leghorn is economical because it requires comparatively small amounts of feed to produce a unit of eggs. This is important because, in an egg operation, feed cost represents about two-thirds of the total production cost.

The Leghorn is small-bodied (about 4½ pounds mature weight) and lays a large number of large eggs. Although the meat is tasty, the Leghorns are not raised specifically for meat because of their slow growth rate and small size.

For both eggs and meat, the American or English breeds are excellent. Some American breeds are Rhode Island Red, New Hampshire, and Plymouth Rock. On islands close to Australia, the Australorp breed may be available. These dual-purpose breeds are relatively large-bodied and produce many eggs. There is also available the hybrid of the cross between the Australorp and the White Leghorn--the Austra-White--in many areas of the Pacific.

Comments on the native chickens found in the different areas of the Pacific are not included here simply because very limited background information is available about them.

Table 2 shows some of the characteristics of the various breeds of chickens.

TABLE 2. The more important characteristics of some representative breeds of chickens

Breed	Standard weight (pounds) Cock	Hen	Type of comb	Color of ear-lobe	Color of skin	Color of shank	Shanks fea-thered?	Color of egg
American breeds								
Plymouth Rock	9½	7½	Single	Red	Yellow	Yellow	No	Brown
Wyandotte	8½	6½	Rose	Red	Yellow	Yellow	No	Brown
Rhode Island Red	8½	6½	Single & Rose	Red	Yellow	Yellow	No	Brown
New Hampshire	8½	6½	Single	Red	Yellow	Yellow	No	Brown
Jersey Black Giant	13	10	Single	Red	Yellow	Yellow	No	Brown
Asiatic breeds								
Brahma (Light)	12	9½	Pea	Red	Yellow	Yellow	Yes	Brown
Cochin	11	8½	Single	Red	Yellow	Yellow	Yes	Brown
Langshan (Black)	9½	7½	Single	Red	White	Blue-Black	Yes	Brown
English breeds								
Australorp	8½	6½	Single	Red	White	Dark Slate	No	Brown
Cornish (Dark)	10	7½	Pea	Red	Yellow	Yellow	No	Brown
Dorking (Silver-grey)	9	7	Single	Red	White	White	No	Brown
Orpington (Buff & White)	10	8	Single	Red	White	White	No	Brown
Sussex	9	7	Single	Red	White	White	No	Brown
Mediterranean breeds								
Leghorn	6	4½	Single & Rose	White	Yellow	Yellow	No	White
Minorca (S.C. Blk)	9	7½	Single	White	White	Dark Slate	No	White
Ancona	6	4½	Single & Rose	White	Yellow	Yellow	No	White
Andalusian (Blue)	7	5½	Single	White	White	Slaty Blue	No	White

STARTING A FLOCK

You can start a small chicken flock in several ways. You can buy day-old chicks from reputable hatcheries, or buy started chicks or pullets ranging in age from 6 to 16 or 18 weeks, or incubate eggs from your neighbor's flock. If you plan to purchase day-old chicks, be sure that the source is a good one. Otherwise, you may be raising chickens that lay poorly and make your operation very uneconomical. This also holds true if you are to purchase started pullets. Generally speaking, it is necessary to buy 25 chicks in order to house 10 pullets, or 50 chicks to house from 18 to 20 pullets. This does not hold true when sexed chicks are purchased, but only when "straight run" (mixed sexes) chicks are purchased.

It was said earlier that no one should do his own breeding without adequate finances and a good knowledge of the principles of genetics. However, if you plan to raise a very small number and a source of commercial chicks is not available in your area, you can buy eggs from your neighbor for hatching. Be certain, though, to check the following:

1. See that the hens are laying at a good rate and that hens and males are in good health and show vigor.

2. See that the ratio of males to females is correct. For White Leghorns, this is 1 male to not more than 18 females. For dual-purpose breeds, the ratio should be 1 male to not more than 15 females. If more males are available, you may use more than the number recommended and lower the ratio. However, you should never put strange males together. The males should be reared in the same pen from the time they are chicks. Otherwise, these "strangers" in the same breeding pen will fight, the weaker ones sometimes being killed. The result will usually be a poor fertility rate in the eggs from these females.

Incubation

You can produce chicks by either natural or artificial incubation. Not all breeds of chickens become broody--characteristic trait of sitting on eggs. One of the breeds that very seldom show this trait is the White Leghorn. Other breeds show varying degrees of this trait.

Provide the broody hen with a nest about 14 x 14 inches, and cushion the nest with material such as wood shavings, straw, etc. Place the hen and the nest in a small, isolated pen that is darkened somewhat, and provide feed and water. The American breeds will normally sit on and incubate very easily up to 12 and possibly 15 eggs. You should set the fresher eggs because these tend to hatch better, especially if no refrigeration facilities are available. If facilities are available, you can hold eggs up to 14 days without any detrimental effect on hatchability. This is important if artificial incubation is to be used. Instead of setting eggs daily, you can set eggs on a regular schedule and not be taking off chicks daily after the first 21 days.

The ideal holding temperature for eggs is between 50 F and 55 F, and about 78 to 80 percent relative humidity. If the eggs are to be held for more than a week, they should be turned at least once a day. Place the eggs on a rack with the blunt end 45 degrees from the vertical. When turning, position the eggs 45 degrees from the vertical in the opposite direction.

Remove the eggs from the cooler a few hours before setting them in the nest. You should realize that the onset of broodiness cannot be predetermined under field conditions. This and the fact that the number of chicks that can be produced at any one time is limited are the greatest disadvantages of natural incubation. However, if you use only natural incubation and have refrigeration facilities, you can store your eggs until a hen becomes broody. In the meantime, you can have the older eggs for table use and need not be concerned with refrigeration space.

Once the eggs are set, it is best not to disturb the hen until after the 22d day. The chicken egg hatches in about 21 days plus or minus a few hours, depending on several things, among which is egg size. Large eggs tend to take longer to hatch than small eggs.

The following shows the differences in incubation periods among the fowls.

Kind of fowl	Incubation period	Kind of fowl	Incubation period
Chicken	21 days	Pheasant	21-24 days
Turkey	28 "	Guinea	26-28 "
Duck	28 "	Ostrich	42 "
Duck (Muscovy)	35-37 "	Pigeon	17 "
Goose	28-32 "	Peafowl	28 "

For artificial incubation, the following conditions should be met:

1. The incubator should be either the still-air or the forced-draft type. If you build your own incubator, you will probably build the still-air type. Make sure the box is built so that there are no cracks or holes other than a small opening at the front base and one in the top for some air exchange. The developing embryos are respiring and need a supply of oxygen, and a buildup of carbon dioxide gas will be detrimental. The size of the air inlet and outlet will depend on the size of the incubator. Heat may be supplied by electric bulbs or lanterns or, if available, a thermostatically controlled heating unit. An example of a commercial force-draft incubator is shown in Figure 7.

2. The temperature for still-air incubators should be about 101 F at egg level. Forced-draft types (air movement is by a fan within the box) should have a temperature of about 100 F. The temperature during incubation should not vary more than 0.5° at any time.

3. Relative humidity should be about 60 percent. In areas of low humidity, you should place a pan of water at the base of the incubator.

4. Oxygen content of the air within the box should be 21 percent, which is the normal content of the air.

5. Carbon dioxide concentration should be 0.5 percent.

6. Set the blunt end of the egg up at a 45 degree angle from the vertical. Turn the eggs odd-numbered times per day--either 3 or 5. They need not be turned after the 17th day of incubation. Before incubation, hold eggs under conditions described for natural incubation.

7. The incubator should be fumigated during each hatch to prevent diseases from being transmitted from the hen through the egg to the chick, and from chick to chick after they hatch but while they are still in the incubator. One of these diseases is pullorum, or bacillary white diarrhea. This disease is caused by the bacterium <u>Salmonella pullorum</u> which can cause up to 100 percent mortality in chicks. Fumigate about

the 18th day of incubation. Before fumigating, remove the eggs from the incubator into a container that will hold heat well. Place 35 grams of potassium permanganate in a nonmetallic container and pour 70 cc. of formalin around the crystals. There will immediately be a reaction and a pungent gas will be given off. Try to avoid inhaling this gas. After about ½-hour of fumigation, replace the eggs in the incubator. This ratio of chemicals should be used for each 100 cubic feet of incubator space.

8. During fumigation, the eggs may be candled (described more in detail later) for fertility and embryo mortality. Hold each egg before the candler (do not twirl) and discard all eggs that are clear or partially clear. Viable embryos will show a clear area only in the air cell.

9. When the chicks are removed from the incubator, they will be soft and wet to the touch. Place them in a box in a warm, draft-free room for about 3 hours before placing them in a brooder. This is to allow the chicks to "harden."

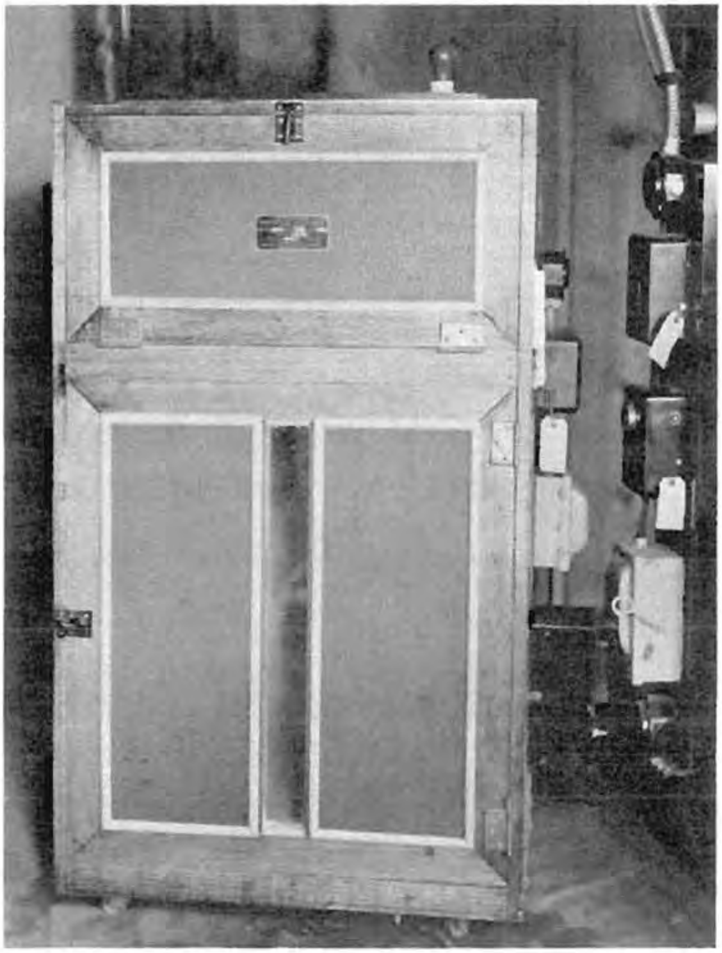


Figure 7. A small combination incubator-hatcher. The bottom portion is used to incubate the eggs for the first 18 days, while the upper portion is used for the last 3 days.

BROODING CHICKS

Chicks hatched by a hen usually do not need extra care because the hen will provide the warmth and protection required by the chicks. If the chicks are to be reared apart from the hen, a brooder is needed. Examples of home-made and commercial types of brooders are shown in Figures 8 through 12. The floor should be of ½-inch mesh wire for brooders such as those shown in Figures 8 and 12, or solid with litter (Figures 11 and 11a). When using the litter system, make sure you select a material such as wood shavings, sawdust, rice hulls or straw which has moisture absorbing properties. Use enough of the material to cover the floor to a depth of 2 to 4 inches. Manage the litter so that it is kept dry at all times. Chicks should be provided an area that is neither too small nor too large. Floor space could be between 0.75 to 1.0 square foot per bird in the litter system, and between 0.50 and 0.75 square foot per bird in the wire floor system.

Brooding temperature should be about 95 F for the first week and 5° lower each succeeding week until no artificial heat is required, usually in about 3 or 4 weeks. Use lanterns or electric bulbs to provide heat for small numbers of chicks and either gas or electric brooders such as those shown in Figures 11, 11a and 12 for brooding large numbers. Regulate the temperature, using a thermometer. Do not use yourself as a measure of proper brooding temperature because it may not be the right temperature for the chicks. No matter what

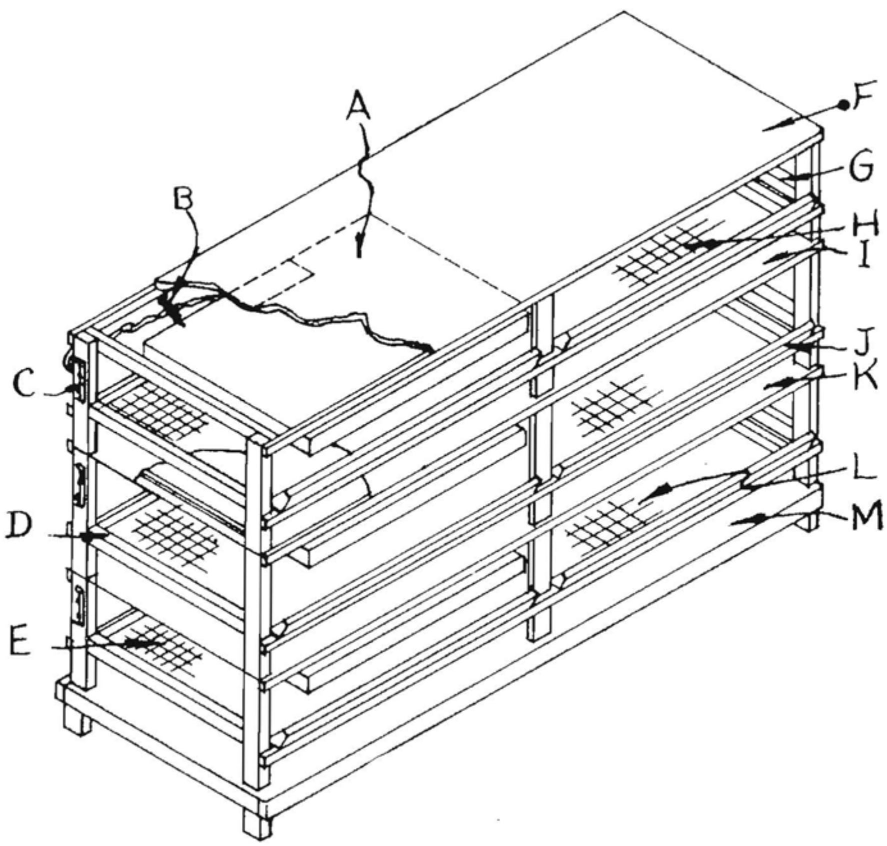


Figure 8.—An isometric view of a homemade type of starting battery brooder. (A)—Electric brooder in each deck (B)—Chain to raise or lower brooder (C)—Socket for brooder (D)—Water trough (E)—½" mesh hardware cloth floor (F)—First deck plywood top (G)—Water trough (H)—½" mesh hardware cloth floor (I)—Second deck top (J)—Feed trough (K)—Sheet metal top (L)—1" x 2" mesh 14-gauge welded wire fabric for chicks to feed through (M)—Sheet metal platform.

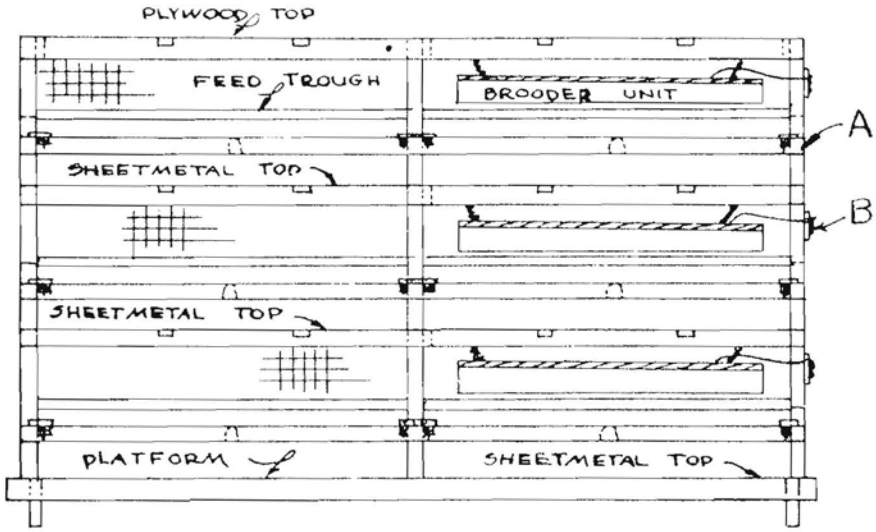


Figure 9.—Assembly of a starting battery brooder. (A)—Water trough at both ends (B)—Sockets and cord to brooders.

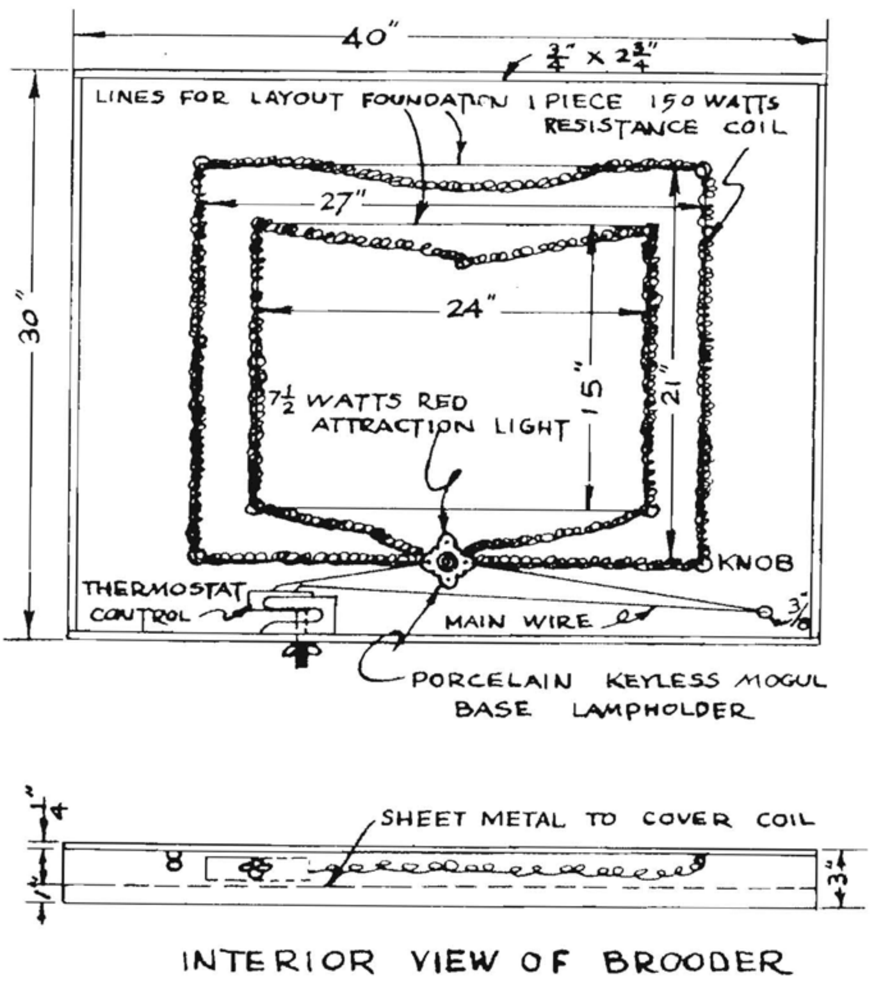


Figure 10.—Detailed construction of electrical heating unit of a starting battery brooder.

BILL OF MATERIAL FOR PLATFORM, ONE DECK, AND BROODER UNIT OF STARTING BATTERY BROODER*

Number of Pieces	Description	Quantity	Ordering List Description
	Platform:		
4	Legs	1 piece	2" x 3" x 2'
2	Side rails	2 pieces	1" x 3" x 12'
2	End rails		
	Hardware:		
1	Sheet metal top	1 only	3' x 9' galvanized sheet metal (26-gauge)
	Individual deck:		
4	Legs	1 piece	2" x 3" x 6'
2	Center legs	5 pieces	1" x 2" x 12'
4	Side rails		
4	End rails		
5	Top supports	1 piece	1" x 2" x 16'
3	Floor supports		
1	Panel for top deck	1 only	¼" x 3' x 9' 3-ply panel
	Hardware:		
	Hardware cloth for floor	1 only	3' x 8' ½" x ½" hardware cloth
	For first and second deck roof	1 only	3' x 9' galvanized sheet metal (26-gauge)
	Wire fabric for sides	22' x 1'	1" x 2" mesh 14-gauge welded wire fabric
2	Nuts to fit rod for floor supports	2	3/16" nuts
1	Rod for floor supports		
2	End rods to hold wire mesh	1 piece	3/16" rod 30' long
4	Side rods to hold wire mesh		
4	Feeding trough		
2	Water trough	1 only	2' x 9' galvanized sheet metal (26-gauge)
24	Galvanized strips to hold trough		
	Brooder or hover:		
2	Sides	1 piece	½" x 3" x 12'
2	Ends		
1	Top of brooder	1 only	¼" x 2½' x 3½' 3-ply panel
	Hardware:		
1	Sheet metal to cover heating coil	1 only	2½' x 3½' galvanized sheet metal

* Electrical fixtures are not included

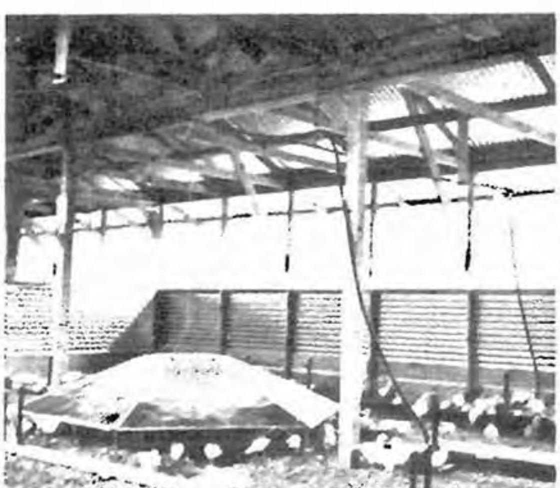


Figure 11. Brooder with hover. One of these hovers is usually adequate for brooding about 800 chicks to 4 weeks of age.

system of brooding you use, the house should be built to give good ventilation but to prevent strong drafts.

Separate the sexes as soon as you are able to tell them apart. For White Leghorns, the distinction between sexes can be made at about 3 weeks of age, but in dual-purpose and heavy breeds, the distinction may not be seen until about the 6th week or later. The males have larger and reddish-colored combs as compared with the females.

Figure 11a. Heat-ray lamp may be used instead of the hover shown in Figure 11. One lamp placed about 18 inches above the floor will provide adequate heat for 100 chicks.

Depending on the availability and cost of feed, the cockerels should be discarded, raised for meat, or possibly raised as future breeders. For the latter, be sure to keep only the more vigorous and faster growing cockerels.

Feed troughs may be made of bamboo in areas where it is available. A trough 4 feet in length will be sufficient for 100 chicks for the first week. Split the bamboo so that two-thirds of it will be used; this will minimize feed wastage. Increase the number of troughs as the birds grow to maturity. At maturity and thereafter, about 4 inches of trough space per bird is adequate. It is always better to give the birds more feeder space than is recommended. You will encounter less difficulty with birds on full feed than otherwise.

Water should be given daily in clean waterers. One gallon per day is sufficient for 100 chicks during the first week. After the chicks mature, 6.5 to 10.0 gallons per 100 birds may be required daily. The water requirements are discussed more fully in the section on nutrition.

Waterers should be so constructed that the chicks will not be able to "bathe" themselves. Otherwise, you may have a lot of drowned chicks during the first few days or many dead ones later on caused by the effects of chilling.

Figure 12. Commercial brooders. There are five identical tiers, each with a thermostatically controlled heating unit. Note the water troughs at the end of the unit and the feed troughs on the side.

If you intend to raise chickens for meat only, your main objective should be to produce the most meat in the shortest period of time on the least amount of feed. To do this, you must start with a good source of meat-type breed or hybrid, feed them an adequate diet (see section on nutrition), provide a favorable environment and practice good management. Unlike egg-type chickens, the meat-type chickens are kept for a short period of time--usually to about 8 or 9 weeks of age (see page 91).

Meat-type chickens are usually raised on litter, whether in small or large numbers, because of the breast blister problem with broilers raised on wire-floor cages or pens. Experience has shown that the incidence of breast blisters is higher in cages than on litter, although research projects in the U.S. are now being concentrated on testing different materials as cage flooring to determine their effectiveness in preventing breast blisters. These blisters are undesirable because they cause downgrading of the carcass in the U.S. system of marketing poultry. They are formed under the skin overlying the mid-portion of the sternum (Figure 3) and are believed to be caused by the constant rubbing of this area against hard surfaces.

Debeaking

Chicks should be debeaked at about 2 weeks of age to prevent cannibalism--a situation in which the chicks or older birds pick on another. This takes the form of toe picking in chicks to feather pulling and vent or tail picking in adult birds. The causes of cannibalism are mostly environmental, so control is a matter of good management. Although many measures of control have been reported, the best method is to debeak the birds properly.

For debeaking, commercial equipment using electricity is available (Figure 13). If there is no source of this equipment in your area, you can debeak with a fingernail clipper or a pair of scissors (Figure 13a). Cut off about half of both beaks (this is the block method) or about one-third of the upper beak only. Have a very hot metal plate available (this is part of all commercial equipment) to cauterize the cut to prevent bleeding. After the cut is made, press the hot metal plate against the cut portion for about 1 second. Immediately after the operation, be sure to provide the birds with lots of cool water and feed.

In all probability, debeaking will be necessary a second time. This should be done when the pullets are about 13 weeks of age. Do not delay debeaking the second time. Beyond 16 weeks of age, debeaking may cause the pullets to be set back and production may not be as expected.

At times you may encounter cannibalism in the laying flock. Since it is undesirable to debeak birds that are laying, an alternate method should be used. If one or two birds in a single pen are being picked, remove these birds from the pen and keep them in isolation and observe the rest of the birds to note whether or not they are still showing the trait. If they are, add 2 percent ordinary table salt to the mash (2 pounds of salt for each 100 pounds of mash). If the feather picking does not stop after 2 days of this treatment, stop feeding the added salt because too much salt is toxic.

Another method you could try is to place extra salt in the drinking water. Add a heaping tablespoon of salt to each gallon of water and place this "salted water" before the birds for only one-half day. Use this water with the added salt in the morning and give just plain water in the afternoon. Do not continue this treatment if cannibalism is not stopped after the third half-day.

Remember that the salt treatment is recommended only as a curative treatment and not as a preventive measure.

Another chore that should be performed while the chicks are in the brooder is vaccination against fowl pox. This should be done when the chicks are about 10 days of age. Fowl pox is caused by a virus carried by the night mosquito, and it can cause heavy mortality in chicks. This disease, and others for which vaccines are available, are discussed more fully under "Diseases."

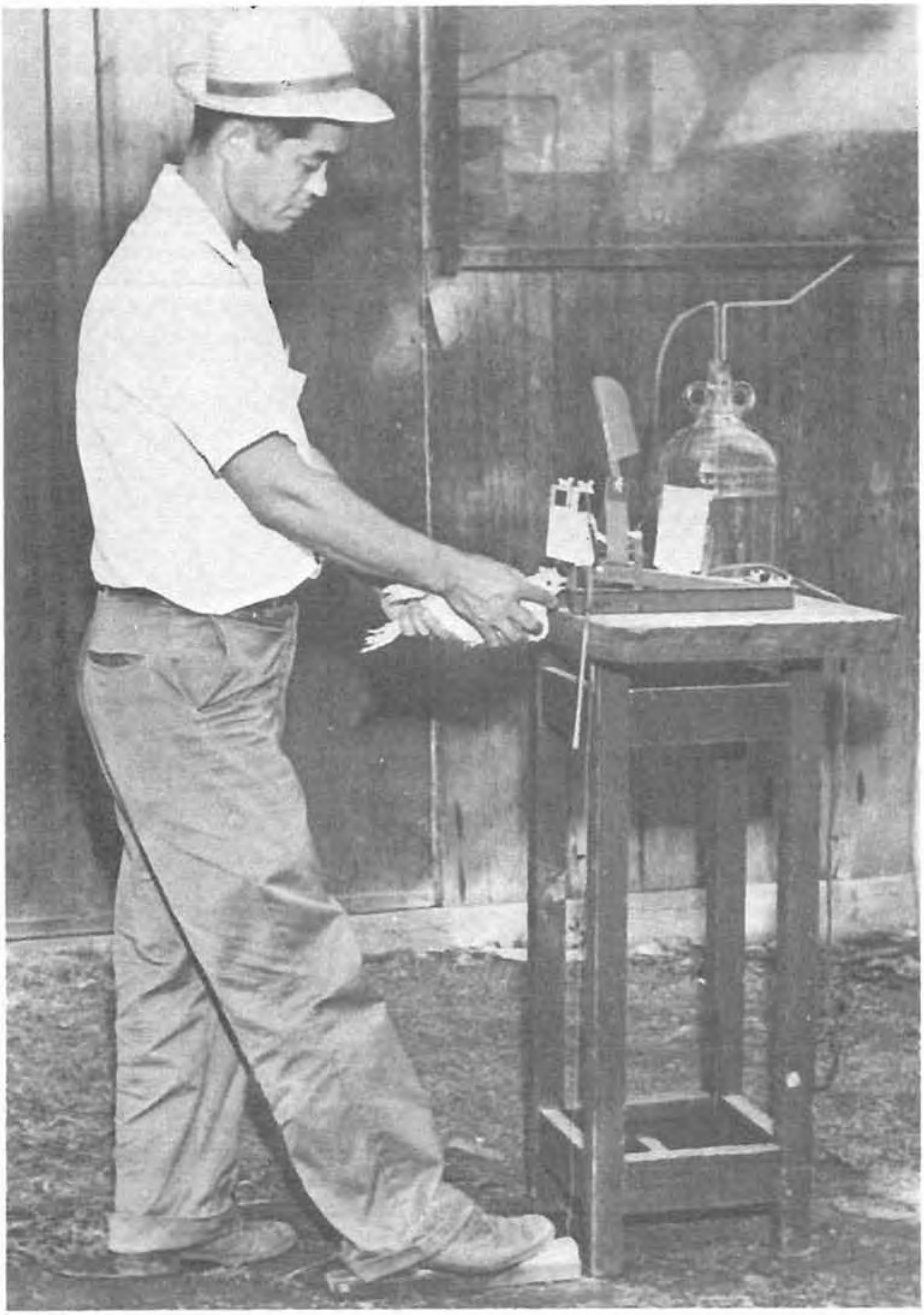


Figure 13. A simple type of commercial equipment for debeaking is placed on a homemade stand and operated with the foot.

Figure 13a. Debeaking with a pair of scissors.

GROWING PULLETS

When the chicks are about 4 weeks of age, move them to intermediate growing houses such as those shown in Figure 14. In hot areas, the roof of these units may be too low to provide a comfortable environment for the chicks. In such cases, you can either locate the units under shaded areas or you can build the units with a higher roof.

No special care is needed while the chicks are in these units. Be sure to supply adequate amounts of feed and water daily.

HOUSING FOR LAYERS

When the birds are about 16 weeks of age, transfer them to the laying house. Small flocks need not have elaborate units. A simple house with an adequate roof is all that is needed (Figures 15 and 16).

The roof should be built high to insure good ventilation and provide a cool environment. This is especially important in the tropics. The walls should not be enclosed with any solid material. Instead, a large area of the four sides should be covered with wire or bamboo slats so that air can move through the house and natural light can enter. Laying chickens need light to stimulate the pituitary gland into secreting hormones which, in turn, stimulate the ovary into activity.

Figure 14. Intermediate growing units common in Hawaii some 20 to 25 years ago.

Small-cage units, such as those shown in Figures 17 through 22, may be used for layers. These units have an advantage over the large pens in that the incidence of disease is reduced and the operator is better able to observe and manage the birds.

Large or small laying pens may also be used to house layers. A floor area of from $2\frac{1}{2}$ to 3 square feet per White Leghorn hen or about 3 to $3\frac{1}{2}$ square feet per Rhode Island Red hen should be provided. It is desirable to raise the floor of these houses about 30 to 36 inches and use 1- x 2-inch mesh wire for the flooring. A solid wooden floor may be used in place of wire. When wood is used, cover the floor with adequate litter material to a depth of about 4 inches (Figures 23 and 24).

If finances are limited and you are not able to build a pen with a raised floor, provide litter material on the dirt floor. Be sure that the dirt is tamped before the litter material is put on it.

Certain areas of the Pacific are subject to hurricanes and typhoons during part of the year. In these areas, laying houses should be built to withstand the strong winds, at the same time allowing for adequate ventilation. Figures 25 and 26 are examples of laying houses used in a typhoon-prone area.

Figure 15. A simple type of cage house. Except for the roof and the floor, all other materials are "homemade."

Figure 16. A cage house with straw thatch for the roof.

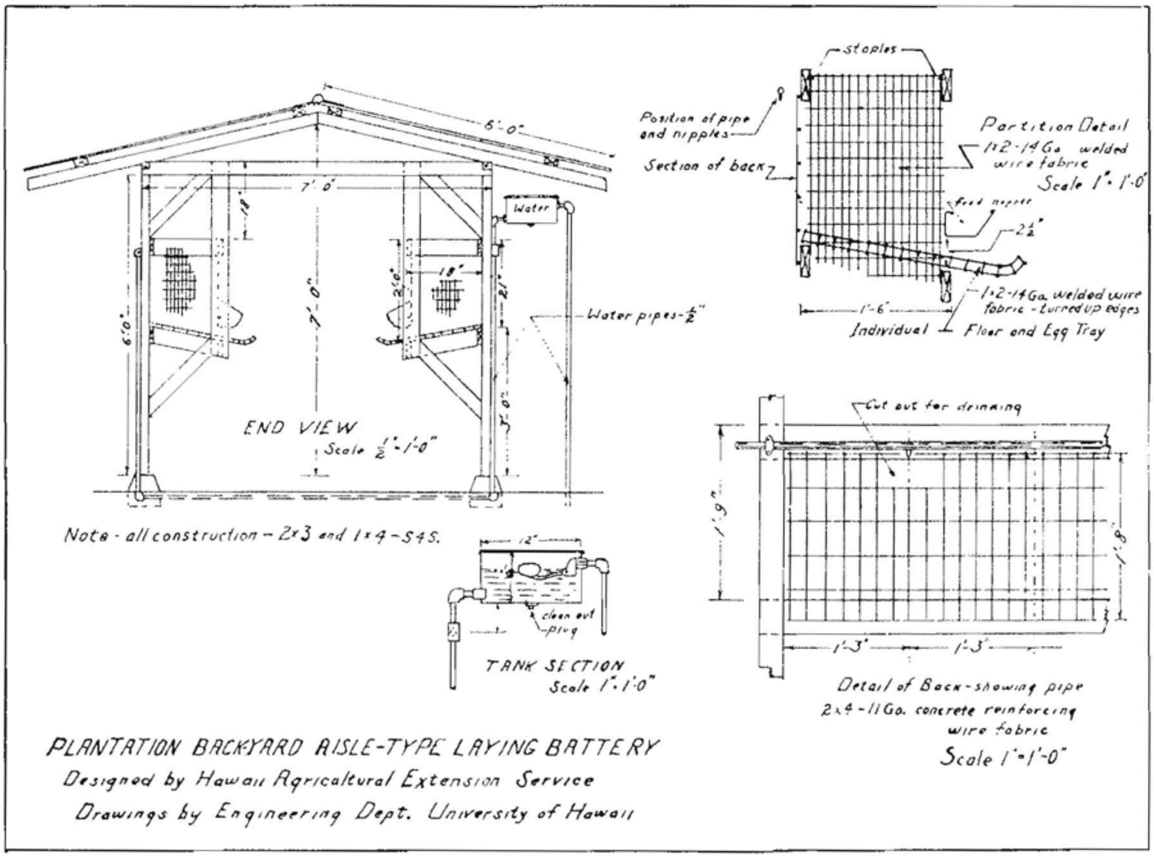


Figure 17. Plan for laying battery showing end view, partitions, nipple water system, and details of the pressure control water tank.

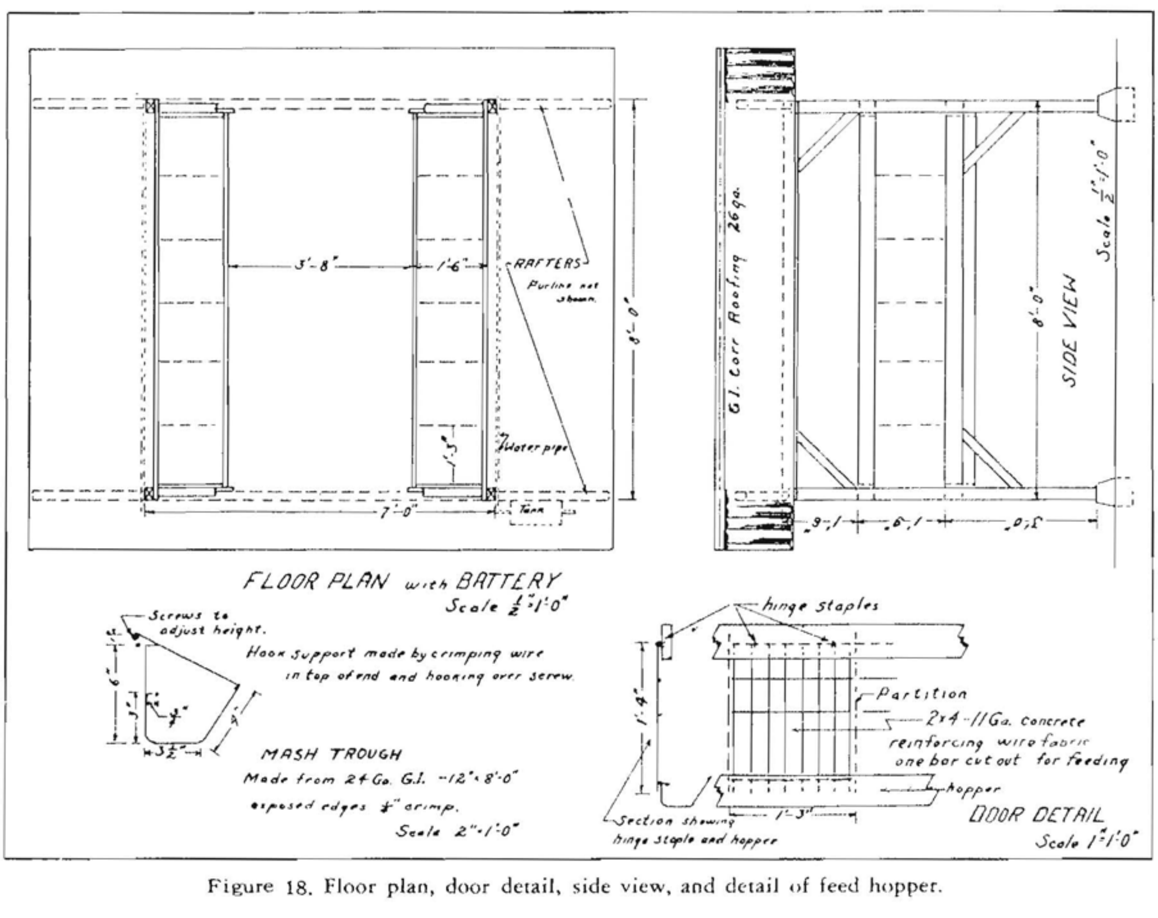


Figure 18. Floor plan, door detail, side view, and detail of feed hopper.

BILL OF MATERIAL

Number of Pieces	Description	Size
	Roofing:	
1	Roof saddle	6" x 6" x 9'6"
10	Galvanized iron corrugated roofing	2' x 6' (26-gage)
4	Purlins	2" x 3" x 9'6"
4	Rafters	2" x 3" x 6'0"
	Main frame:	
4	Corner posts s-4-s	2" x 3" x 6'0"
2	Ties s-4-s	2" x 3" x 7'0"
2	Plates s-4-s	2" x 3" x 8'0"
	Battery frame:	
4	Hanger s-4-s	1" x 4" x 4'0"
12	Braces s-4-s	2" x 3" x 1'9"
4	Braces s-4-s	2" x 3" x 2'0"
2	Top frame s-4-s	1" x 4" x 8'0"
2	Top frame s-4-s	1" x 4" x 7'4"
4	Top frame s-4-s	1" x 4" x 1'4½"
2	Bottom frame s-4-s	1" x 4" x 8'0"
2	Bottom frame s-4-s	1" x 4" x 7'4"
4	Bottom frame s-4-s	1" x 4" x 1'8"
	Hardware:	
2	Wire fabric battery top	2" x 4" mesh concrete reinforcing fabric 7'6" long x 18" wide
2	Wire fabric battery back	2" x 4" mesh concrete reinforcing fabric 7'6" long x 20" wide
10	Wire fabric partitions (cut on slope)	1" x 2" (14-gage) 2'0" long x 16" wide
4	Wire fabric ends	1" x 2" (14-gage) 1'10" long x 15" wide
12	Wire fabric doors	2" x 4" mesh concrete reinforcing wire 1'6" long x 14" wide
12	Wire fabric egg trays	1" x 2" (14-gage) 28" long x 16" wide
2	Galvanized sheet metal feed troughs—sides and bottom	12" x 8' (24-gage)
4	ends	6" x 6" (24-gage)
4	Hooks (galvanized wire)	4" long (11-gage)
1 lb.	Fence staples (galvanized)	¾"
½ lb.	Nails (galvanized)	8d
1 lb.	Nails (galvanized)	6d
½ lb.	Roofing nails (galvanized)	8d
1	Cut-off valve	½"
1	Float valve	
1	Pressure tank (galvanized)	6" x 6" x 12"
	Galvanized water pipe	½"
6	Nipples (drip)	
1 gal.	Stain or paint	
4	Footing blocks (concrete)	5" x 5" top, 10" x 10" base, 8" height

Figure 19. A small-cage unit.

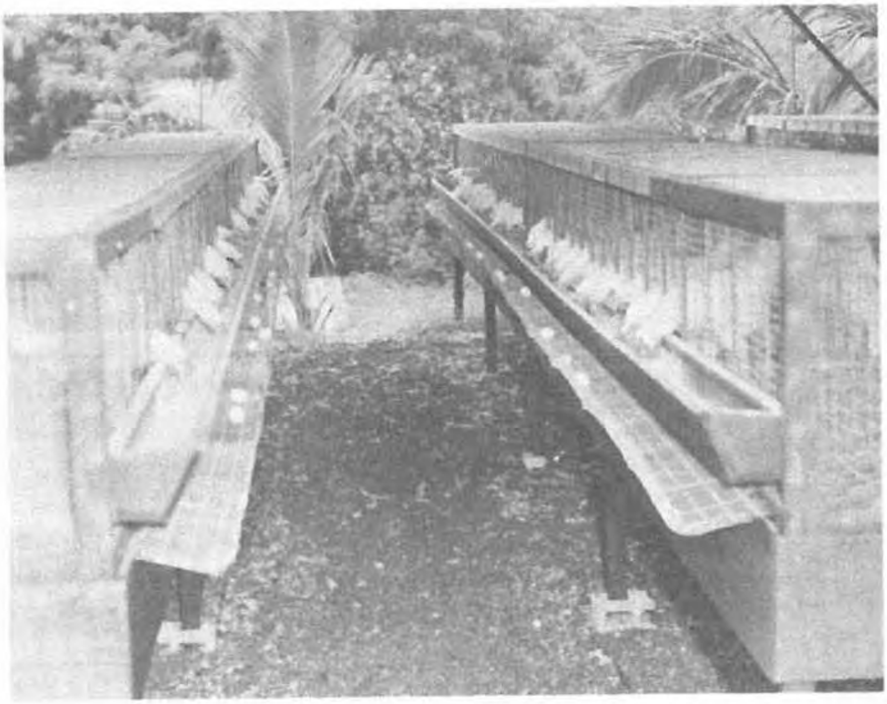


Figure 20. Individual cages (12" wide x 18" deep), each housing 2 or 3 layers.

Figure 21. Individual cages with floor raised 36 inches above ground level.

In large pens, roosts made of 2-inch lumber with the upper side rounded off should be provided. Roost space of about 8 to 10 inches per bird is desirable. Egg nests should also be provided. Each should be 12 inches wide, 14 inches deep, 14 inches high, and with a 3-inch lip on the lower front end to contain the nesting material. There should be one nest for every 4 or 5 layers. The roost and the nest should be about 30 inches above the floor level of the pen.

The discussion so far on houses for all age groups of birds has been for the confinement system of raising chickens, where you would have total control over the chickens. All chickens being raised for either eggs or meat should be raised in confinement, especially in the tropics. Chickens on many Pacific islands are allowed to roam free. They are usually not fed properly and must locate their own food. Included in their diet will be insects, some of which are carriers of internal parasites of chickens. Because of this, it is probable that the egg production of these hens is not as good as it would be if they were fed an adequate ration and kept away from insects by being confined. It is also possible that a good percentage of the few eggs that are produced is serving as food for predators. The hen will lay her eggs by habit in a place that is somewhat dark and off the ground. If the owner knows these spots, he will be able to get most of the eggs. If he does not, he may be spending a lot of fruitless hours searching for the eggs.

Figure 22. Colony cages are expanded forms of the individual cages, each housing up to 25 layers.

Figure 23. A small, family-type laying pen capable of housing about 24 hens.

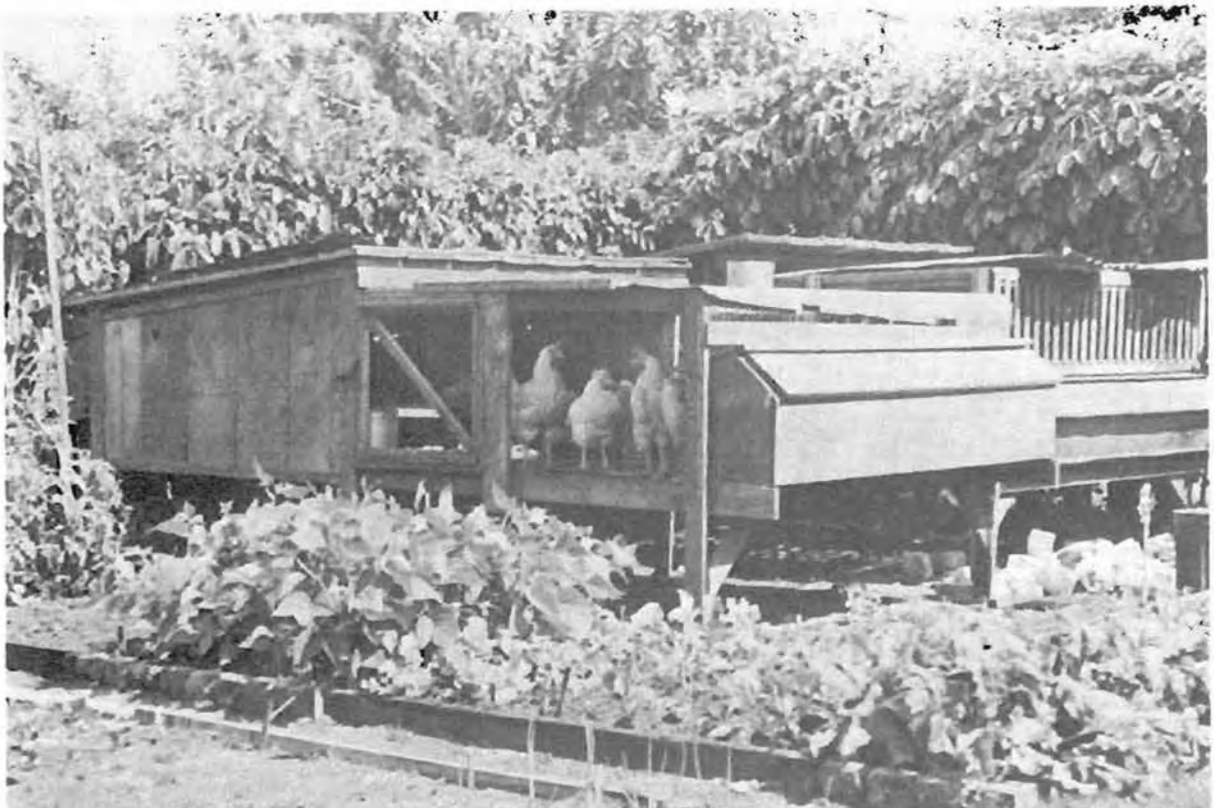


Figure 24. Another type of laying pen that was common in Hawaii about 20 years ago.

Figure 25. A large cage house on a farm in the Ryukyu Islands. The house is constructed to withstand strong winds but allows for natural ventilation.

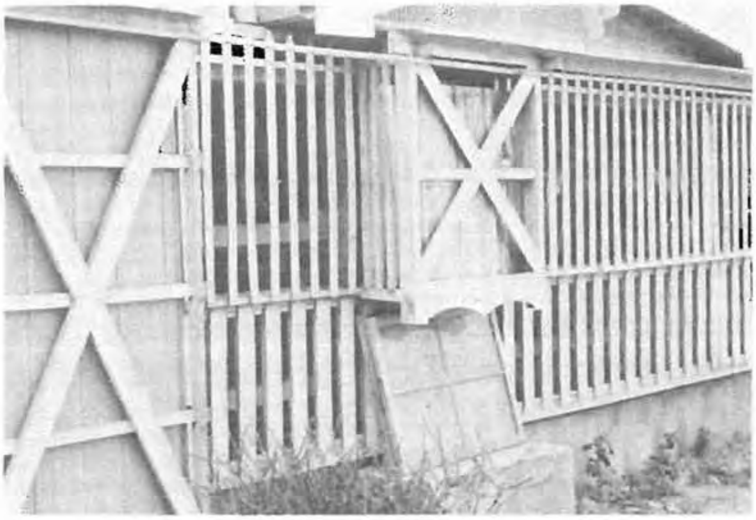


Figure 26. Another type of cage house constructed to withstand strong winds. There are two lath "walls" on this house, one movable (sliding) to completely close the house during typhoons.

ARTIFICIAL LIGHTS

After the layers are housed, several routine tasks must be done regularly. One of these is to see that the birds receive 14 hours of light each day after they have matured. In general, egg production will decline as the day length becomes short. There is no problem when the natural day length is increasing; but, during the season when it is decreasing and during winter when the day length is less than 14 hours, egg production will decline. What can you do to prevent this decline? In areas where electricity is available, you can provide artificial lights to supplement natural ight, according to the example given below.

Lighting System Design

Light levels are measured in foot-candles, and recommended levels can be provided in your poultry house by either incandescent or fluorescent electric lamps. The visible light output in electric lamps is rated in lumens. A rating in lumens per lamp gives the total amount of visible light emitted from a single lamp.

The following list shows the approximate lumen per lamp output for common sizes of incandescent and fluorescent lamps.

Average Lumens per Lamp

Incandescent

Watts	Lumens
15	125
25	225
40	430
50	655
60	810
100	1,600
150	2,500
200	3,500

Fluorescent

Watts	Lumens
15	500 to 700
20	800 to 1,000
40	2,000 to 2,500
75	4,000 to 5,000
200	10,000 to 12,000

In poultry houses, light levels at bird height can vary from less than 1 foot-candle of artificial light to 10,000 foot-candles of direct sunlight. In most artificially lighted poultry houses, however, light levels range from 1 to 30 foot-candles.

Two lumens of output per lamp for each square foot of floor area provide an average light level of about 1 foot-candle in most poultry houses.

This ratio accounts for the efficiency of the entire lighting system, including lamp output, reflectance of walls, and other factors. Clean lamps occasionally to maintain lumen output.

Arrange lamps so they will provide nearly uniform lighting of 1 foot-candle at bird level. Normally, the lamp fixtures will be installed in rows the length of the poultry house. The distance from the two outside rows of lamps to the walls should be no more than the distance from the lamps to the floor; and the distance between lamps and between rows of lamps preferably should be 1½ times (but no more than 2 times) the distance from the lamps to the poultry. In cage layer houses, the lamps are normally located between rows of cages.

The following example shows how you can determine the number and size of lamps you should use in your lighting program.

Suppose your poultry house is 40 feet wide and 144 feet long, and your lamps will be installed 8 feet above the poultry. If the outside rows of lamps are installed 8 feet from the walls, 24 feet remain between the two rows. A row of lamps down the middle of the house provides the required spacing.

Next, determine the number of lamps needed in each row. Maximum spacing is, of course, 16 feet, but a 12-foot spacing is desirable. Since your poultry house is 144 feet long, 12 lamps per row spaced 12 feet apart is a good solution. The lamps at the ends of the rows will be 6 feet from the walls at each end of the house. This gives three rows of 12 lamps each in your house, a total of 36 lamps.

Next, determine the size of lamps required. You know that floor space equals 5,760 square feet, and 2 lumens of lamp output per square foot is needed to obtain an illumination level of 1 foot-candle. Multiply 5,760 by 2, and you find a total of 11,520 lumens is required to obtain the necessary light level of 1 foot-candle. To find the size of lamp, divide the number of lamps into the total lumens. This gives the lumens required per lamp. Select a size lamp from the list on page 32. When the lumen per lamp falls between lamp ratings, use the next larger size, or recalculate using other lamp spacings. In this example, divide 11,520 lumens by 36 lamps. This gives 320 lumens per lamp. From the list on page 32, you find that a 40-watt incandescent lamp or a 15-watt fluorescent lamp would give the required lumens for 1 foot-candle at the bird level.

Both incandescent and fluorescent lamps have been used successfully in lighting poultry houses. Incandescent lamps normally are used in poultry houses with low ceilings, 7 to 8 feet.

The cost of lamps, fixtures, and installation of incandescent lamps is less than for fluorescent lamps, but incandescent lamps cost more to operate and they produce fewer lumens per watt. Incandescent lamps last only 750 to 1,200 hours; fluorescent lamps last from 5,000 to 10,000 hours. The light output of most fluorescent lamps decreases when the air temperature drops below 60 F.

Keep in mind these two principles regarding artificial lights: (1) Do not give artificial lights to young pullets before they begin to lay eggs. If you do, it will result in early maturity, small initial egg size, and a possible shortening of the first laying year. (2) Do not shorten the day length after the hens start to lay. If you do, some layers may stop egg production.

CULLING

Another regular task is culling or removing nonlaying and low-producing hens from the flock. Unless diseased, these birds are suitable for home meals or marketing. Start culling when the chicks are day old. Cull and dispose of unthrifty chicks. Even if they do survive, the chances of their becoming productive are very poor.

By culling regularly, you:

1. Keep the egg production rate of the flock high.

2. Reduce the spread of disease from bird to bird.

3. Save the cost of feeding unproductive birds. (A hen will eat about 7 pounds of feed per month when she is not laying, and a little more when she is laying).

4. Provide more space for the remaining birds.

Culling can be done during the day if the birds are housed in cages. If they are housed in pens, it is better to cull at night by using a flashlight to spot the culls on the roost. Why at night? Because there is less disturbance to the birds at night than during the day. It is not a good practice to disturb the layers once they are housed.

When culling, consider the general appearance and the health of the bird, as well as the specific indicators of egg-laying capacity listed on the following page. Culling is not simple unless you are an experienced poultryman. However, as you work more and more with chickens, the task will become fairly easy. One note of caution: do not be too "cull conscious." That is, do not cull indiscriminately; otherwise, you will find yourself with very few layers at the end of the year. Be especially slow to cull when the pullets are beginning to mature sexually. Pullets will not mature at the same time because of individual inherited differences and because of individual differences in the reaction to certain management practices. You will notice that time of laying the first egg will differ with each pullet. During this period, you should not cull pullets that are slow in maturing. Unless there are obvious signs of disease, you should allow about 2 months after the first egg in the flock is laid before culling the late-maturing pullets.

CHARACTERISTICS IDENTIFYING LAYERS FROM NONLAYERS

Laying hen	Character	Nonlaying hen
Large, red, waxy, full	COMB	Small, pale, scaly, shrunken
Bleached or bleaching	BEAK	Yellow or becoming yellow
Bright, prominent	EYE	Dull, sunken
Bleached	EYELIDS	Yellow
Bleached	EYE RING	Yellow-tinted
Neat, refined	HEAD	Beefy, crow head
Flexible, wide apart	PUBIC BONES*	Stiff, close together
Deep, soft, pliable	ABDOMEN	Shallow, tough, tight
Large, moist, bleached	VENT	Dry, puckered, yellow

*The ends of the pubic bones can be located laterally to the vent.

CHARACTERISTICS INDICATING RATE OF PAST PRODUCTION

Good layer	Character	Poor layer
Completely bleached	BEAK	Yellow or becoming yellow
Bleached	EYE RING	Yellow
Bleached	EARLOBES	Yellow
Bleached	SHANKS	Yellow
Late	MOLT	Early
Worn, soiled	PLUMAGE	Glossy, slick, loose
Seldom	BROODINESS	Often

CHARACTERISTICS INDICATING ABILITY TO LAY

Good layer	Character	Poor layer
Alert, friendly, active	TEMPERAMENT	Dull, listless
High vitality	HEALTH	Low vitality
Wide, long, straight	BACK	Narrow, short, tapering
Deep	BODY DEPTH	Shallow
Long, springy	RIBS	Short, stiff
Large, deep, strong	HEAD	Shallow, weak, crow head
Neat, clean-cut, refined	FACE	Coarse, beefy, wrinkled
Bright, prominent	EYE	Dull, sunken
Short, stout	BEAK	Long, thin
Soft, thin, silky, loose	SKIN	Coarse, thick, dry, tight

REPLACEMENT PROGRAM

A hen is capable of laying up to 4,000 eggs if she lives long enough, but production is not necessarily continual. After each laying year, most hens will molt the old feathers and grow new ones. The time of molt depends on the inherited characteristic we call "persistency of production." And the rate of egg production, which we call "intensity of production" or "rate of lay," declines with each succeeding year. It is, therefore, the usual practice to keep layers only for the first 14 to 16 months of egg production. The birds are then slaughtered, processed, and sold in the markets as "stewers" or "stewing hens." Or they may be used for the family meals.

To have a constant supply of eggs, you would need a second laying unit of birds of another age group. With these laying units, you can have an orderly pullet replacement program and a steady supply of eggs during the year and from year to year. One method is to start your replacement pullets about 6 months before the first group is to be terminated. This means the replacements will have been laying for about 1 month when the first group's "laying year" is finished. If all factors are favorable, you can replace your old hens more often.

Force molting

In recent years, commerical operations in the United States have been force-molting the layers. Instead of terminating the layers after 14 or 16 months of production, poultrymen force-molt a part of or an entire flock after they have completed 12 months of production. More recently, molting has been forced after 8 and even 6 months of egg production.

Force molting is inducing controlled molt in a flock. It is done for several reasons, but the principal one is lack of finances to purchase replacement pullets, either as day-old chicks or started pullets.

There are several methods of inducing molt in chickens. One of these is by starvation. This is, at present, the most practical and economical method. There are many variations of the starvation method. Two techniques are:

1. Remove feed and starve layers for 10 days. After this period, feed whole milo for 22 days; full feed the milo--that is, feed all that the layers will consume. Then feed a 17 percent protein mash. Artificial lights are turned off for 31 days.

2. Start by turning off lights and removing water, but continue to feed at the rate of 16 pounds of laying mash per 100 birds per day for 21 days. Then full feed. On the 4th day, turn on water. Turn on lights 8 weeks after the start of the molt.

After starvation treatment, the layers will reach 50 percent production (production may not stop completely) after the 7th or 8th week, and will continue to produce at a high rate (although not as high as pullet flocks) for about 8 months.

Depending on when you molt your birds, here's how you might manage one flock of layers during approximately a 2-year period of egg production (about 2½ years of age).

1. By molting at 8-month intervals, you can molt a flock twice, resulting in three 8-month production periods (a total of about 28 months).

2. By molting at 12-month intervals, you can molt a flock once, resulting in one production period of 12 months and a second production period of about 8 months.

Be sure to molt only those flocks that have been producing well and are healthy. Otherwise, the flock will not produce well even after the molt. You should also cull the flock before molting.

NUTRITION

The chicken must be fed an adequate diet if it is to perform according to its genetic potential. Nutrient requirements are determined by age and utility. The chicken must be fed the available feedstuffs in the proper proportions to meet these requirements. It is essential that any specific ration meet the following standards:

1. The ration must meet the nutrient requirements of the bird.

    a. Protein (essential amino acids).

    b. Energy (carbohydrates and fats). In poultry nutrition, energy is commonly expressed as metabolizable energy (M.E.).

    c. Vitamins.

    d. Minerals. Of primary importance is a proper ratio of calcium and phosphorus and a proper amount of salt (sodium chloride).

    e. Water. This is the most important nutrient.

2. The ration must be palatable.

3. A good ration generally includes a variety of feedstuffs. This helps to improve the balance of the ration and prevent nutritional deficiencies. This requirement is not critical where synthetic amino acids and mineral and vitamin mixes are added to the ration.

4. Proper levels of the ingredients should be used. Some feed ingredients give good results at low levels but poor results at high levels. Examples are cottonseed meal, tuna meal, and meat and bone

meal.

5. Avoid feed ingredients that cause rancidity. Rancidity reduces palatability and can destroy certain vitamins.

The requirements of chickens for protein, vitamins, and minerals, as published by the National Research Council of the United States, are given in Table 8. However, the actual rations fed to the chickens must contain greater quantities of certain of these nutrients for the following reasons.

The chicken eats to meet its energy requirements. The amount of feed consumed by the chicken, therefore, depends primarily on the energy content of the ration. In simple terms, energy is the ability or capacity to do work.

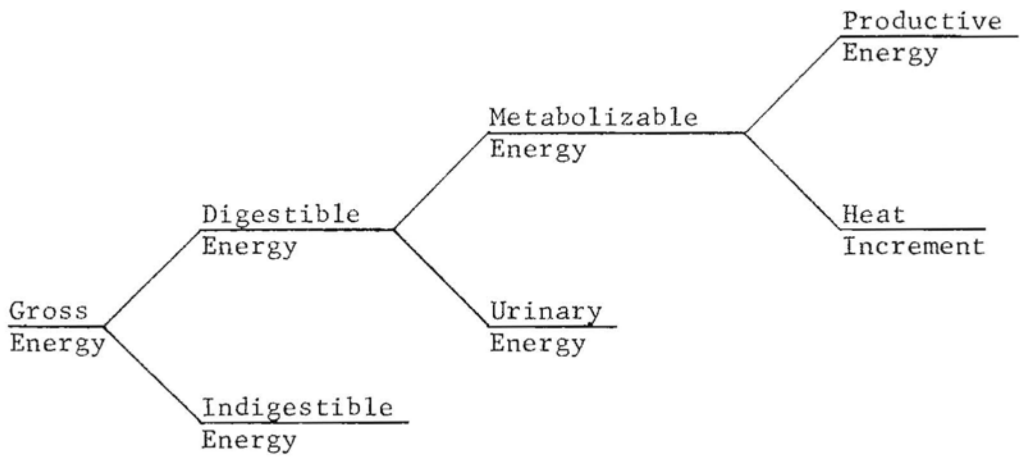
Feedstuffs contain energy--chemical energy--which, when slowly burned (oxidized) in the animal body, can be used to maintain normal body functions. Energy is needed for digestion, assimilation, excretion, respiration, circulation of the blood, temperature control, neural activity, reproduction, and growth. In addition, there are energy requirements for muscular activity associated with eating, drinking, and other voluntary movement.

The smallest unit of energy is the calorie. It is equivalent to the amount of heat needed to raise 1 gram of water 1 C. Energy is measured in a laboratory apparatus known as a bomb calorimeter. A small weighed sample of a feedstuff is burned in pure oxygen under pressure in a combustion chamber surrounded by a jacket of water. The resulting rise in water temperature is accurately recorded and the caloric value of the feedstuff calculated.

In working with poultry rations, we generally use a larger unit of measure--the kilocalorie (1000 calories). Total or gross energy of a ration or feedstuff is expressed as X number of kilocalories per pound (kcal/lb). Sometimes a still larger unit may be used, called a therm. A therm = 1000 kilocalories.

When feed is consumed, not all of the energy potential of the feed as measured by the bomb calorimeter is available for maintaining body functions. Some of it is lost in the process of digestion and metabolism. This partitioning of the total energy of a feedstuff is diagrammed on the following page. The first loss occurs in the digestive tract when a portion of the <u>gross energy</u> fails to be assimilated and is excreted by the bird in the feces (indigestible energy). That portion which is assimilated is <u>digestible energy</u>. However, not all digestible energy is available for "useful work." A portion is lost as <u>urinary energy</u>. That which remains is known as <u>metabolizable energy</u> (M.E.).

There is still another loss called <u>heat increment</u>, which is the energy "wasted" in the form of heat generated by chemical reactions during digestion and metabolism. Heat increment can be partially used to maintain body temperature in cold environments, but relying on feed energy to overcome the effects of inadequate housing is not considered economical.



When the loss of energy in the form of heat increment is subtracted from metabolized energy, the remainder is called productive energy (P.E.), for it is the net energy available for growth, reproduction, and maintenance.

Several years ago, P.E. values for feed ingredients and complete rations were commonly used. The trend now is to evaluate feedstuffs on the basis of their M.E. values. The main reason for the shift is that M.E. values can be more accurately determined and are more reproducible. Most nutritionists now favor M.E. values, which are roughly 40 to 50 percent larger than equivalent P.E. values.

Not all feed ingredients are equal in either gross or metabolizable energy. Differences in chemical composition account for considerable variation. For example, fats yield a much higher quantity of energy per pound than do carbohydrates or proteins. Alfalfa meal, which is high in fiber, has a high fecal loss due to low digestibility. Most protein supplements have a much higher loss of urinary energy than the grains. On the other hand, the grains tend to produce a higher heat increment.

Even individual ingredients may vary in caloric density. Corn samples, for instance, may differ in M.E. value, depending upon their moisture conten, protein level, and particle size (whole, cracked, or ground).

The table on the following page gives typical M.E. values for common ingredients in poultry rations. Note the decline in energy level among the feed grains as fiber content increases. The protein supplements as a group are low in M.E. and would not be used as primary sources of energy in a ration. In contrast, fats, such as grease and tallow, are very high in M.E. per pound and are extensively used in producing high-energy rations.

Metabolized Energy Values for Feed Ingredients

	kcal/lb.		kcal/lb.		kcal/lb.
Corn	1560	Fish Meal	1350	Vegetable Oil	4000
Wheat	1500	SOB Meal, 50%	1150	Grease	3500
Milo	1480	SOB Meal, 45%	1020	Tallow	3500
Barley	1290	Meat & Bone Scrap	900		
Oats	1190	Cottonseed Meal	830		

Several factors influence total energy needs of the bird. One of these is body size. In the following table, note that, as body weight increases, the laying hen increases feed consumption. This table assumes that egg production rate and energy level of the feed are held constant.

Body weight	Feed/100 hens/day
4 lb.	22.0 lb.
5	24.9
6	27.5

70% production--1350 kcal/lb. feed

This relationship holds because larger birds require more energy for body maintenance. However, the increased requirement is not linear; that is, a 6-pound bird is 50 percent larger than one weighing 4 pounds, but she does not consume 50 percent more feed. This is explained, in part, by the lower ratio of body surface to body weight of the larger bird and, therefore, the proportionately lower maintenance requirement.

A second factor affecting energy needs is growth rate. Energy requirements for growth cannot be stated as precisely as those for amino acids, vitamins, and minerals. Higher energy rations are normally fed to birds raised for meat production in which the goal is maximum growth rate. For pullet replacements, growth rate is not as critical, so rations of lower energy usually can serve as well and at less cost.

Pullets just coming into egg production are still increasing in body weight. Their needs for energy, as well as other nutrients, will therefore be greater than for fully mature birds of equal weight and egg production rate.

Energy is stored in each egg--approximately 90 kcal.--so egg production is another factor affecting energy needs. As the rate of production goes up, feed intake increases. This is illustrated below.

Production Rate %	Daily Feed Intake lb./100 hens	Feed Efficiency lb./doz
0	15.8	-
20	17.6	10.5
40	19.3	5.8
60	21.1	4.2
80	22.9	3.4

4-lb. hens--1350 kcal/lb. feed

Note that, at zero production, each bird consumes 0.158 pound of feed or 213 kcal. of energy. This approximates the daily requirement of a 4-pound hen for maintenance purposes only. Although an egg contains about 90 kcal., it is estimated the hen needs about 120 kcal. of feed energy (above maintenance requirements) to produce an egg because 100 percent conversion efficiency is not achieved. Thus, total requirements reach 330 to 335 kcal. for each day an egg is laid. Hens in a flock at 80 percent production would each need, on the average, about 310 kcal. daily; 213 + (0.8 x 120).

Feed efficiency (pounds feed/dozen eggs) improves with a rise in production rate. For birds completely out of production, it jumps dramatically to infinity (∞), and for those weeks of top production it may drop below 4.0. The exact value depends not only on production rate but also on energy levels of the feed. High-energy feed should lead to better feed efficiency, but this does not necessarily mean production costs will be lower.

The normal body temperature of the chicken is 106 F to 107 F. Under usual housing conditions a bird is constantly losing heat to its environment. There is a "zone of thermal neutrality" (58 F to 78 F) within which the heat produced by normal body activity approximately equals the heat lost to the environment. This is sometimes referred to as the "comfort zone." As temperatures drop below this range, the birds must eat more feed to maintain body temperature. At high temperatures, extra energy actually may be expended (for example, in panting) to increase the loss of heat. It is thus clear that environmental temperature directly influences energy requirements, and there will be seasonal variation in feed consumption. The data below show this principle.

Feed Energy Level	Daily Feed Intake	
	Winter	Summer
kcal/lb.	lb./100 hens	
1200	26.3	23.4
1300	24.2	21.5
1400	22.2	20.0

Knowledge of energy principles is of little value in itself. To take advantage of these concepts, you must put them to work in minimizing feed costs. This can be done in several ways:

1. In choosing the type and strain of bird for your farm, carefully consider body size. Everything else being equal (production, livability, egg size), the smaller bird will yield more profit because of lower maintenance requirements. However, seldom is "everything else equal," so some compromises may be required. Poultry breeders are now working on a "midget" bird that reportedly matures at around 3 pounds. If it performs and lives well, this may be a major breakthrough in reducing costs.

2. To lower energy needs, reduce body activity. The more activity voluntarily engaged in, the greater will be the feed intake. Although supporting data are lacking, birds confined to cages may expend less energy than those in large pens. Bird density in a cage could be a factor in activity level, but there are practical limitations to increasing density for this purpose. Voluntary activity is stimulated by light. In many houses, it is possible to reduce light intensity

without affecting egg production. The same can be said for lowering the light-to-dark ratio. Also, it is generally maintained that less energy is expended in eating pellets than mash.

3. Keep birds within their zone of thermal neutrality. Environmental temperatures several degrees above or below this range for a few hours are not serious. However, prolonged periods of excessive heat or cold not only affect feed efficiency but also production rate and mortality.

4. Adjust the nutrient level of the ration, particularly protein and calcium, to feed intake as governed by energy needs. Such adjustments are particularly important during hot summer weather. This is when feed consumption drops and, as a result, daily intake of vital nutrients falls below optimum levels. In winter, too, changes in the ration are required to avoid wasting costly nutrients when feed intake increases to meet higher energy needs.

In the following table, note how the daily protein requirement changes with production rate, and how the percent protein in the ration must be related both to feed intake and percent production. As an example, a flock laying at a good rate (70 to 80 percent) during the summer when daily feed intake might drop to 20 pounds/100 birds, would require a relatively high level of protein in the ration (19.2 percent). On the other hand, a flock nearing the end of its production year (50 to 60 percent lay) during cold weather when feed intake is 24 pounds/100 birds, could get by with a lower level of protein (14.3 percent).

% Production	80+	70-80	60-70	50-60
Daily protein required (g)	18.5	17.5	16.6	15.6
lb. feed/ 100 hens		% Protein		
18	22.6	21.3	20.3	19.0
20	20.3	19.2	18.3	17.2
22	18.5	17.5	16.6	15.6
24	16.9	16.1	15.2	14.3
26	15.7	15.1	14.1	13.2
28	14.6	13.8	13.1	--

The same principle holds for the adjustments in calcium levels. Percentages of this important mineral in the ration must rise with increased production and decreased feed intake. When production drops or feed intake increases, the calcium levels can be adjusted downward.

% Prod.	90	80	70	60	50
lb. feed/ 100 hens		% Calcium			
18	5.0	4.4	3.9	3.3	2.8
20	4.5	4.0	3.5	3.0	2.5
22	4.1	3.6	3.2	2.7	2.3
24	3.7	3.3	2.9	2.5	2.1
26	3.4	3.1	2.7	2.3	1.9
28	3.2	2.8	2.5	2.1	1.8

Feed consumption of young chickens

A question often asked is how much feed is consumed by young chickens--broilers and egg-type pullets. Table 3 shows the growth rate and feed consumption at various ages of White Leghorns and heavy breeds. Similar data for broiler chicks to 9 weeks of age are shown in Table 4. Keep in mind that these data do not apply to all situations; they are presented here as a guide in determining the feed consumption in your flock.

TABLE 3. Feed and time required to obtain certain average live weights with common breeds of chickens

(kg)	Kind of chicken and quantity of feed required per bird				Kind of chicken and age at which certain live weights are reached			
Average	Wht. Leghorns		Heavy breeds		White Leghorns		Heavy breeds	
Live	F	M	F	M	Females	Males	Females	Males
Weight	kg	kg	kg	kg	wk	wk	wk	wk
0.25	0.5	0.45	0.45	0.4	3.2	2.9	3.0	2.7
0.5	1.15	1.0	0.95	0.9	5.8	5.0	4.7	4.3
0.75	1.85	1.6	1.55	1.45	8.2	6.8	6.1	5.5
1.0	2.65	2.35	2.25	2.1	10.6	8.3	7.5	6.7
1.25	3.8	3.15	3.05	2.75	13.3	9.7	8.9	7.8
1.5	5.3	4.1	3.9	3.45	16.4	11.3	10.3	8.7
1.75	8.2	5.3	5.0	4.25	19.8	13.0	11.6	9.7
2.0			6.2	5.1			13.0	10.6

TABLE 4. Weekly average weight and gain for commercial broilers

Week	Males		Females		Mixed Sexes	
	Avg. wt. (lb.)	Gain/wk. (lb.)	Avg. wt. (lb.)	Gain/wk. (lb.)	Avg. wt. (lb.)	Gain/wk. (lb.)
Initial	.09	---	.09	---	.09	---
1	.23	.14	.22	.13	.23	.14
2	.48	.25	.45	.23	.47	.24
3	.87	.39	.77	.32	.82	.35
4	1.32	.45	1.14	.37	1.23	.41
5	1.86	.54	1.58	.44	1.72	.49
6	2.52	.66	2.06	.48	2.29	.57
7	3.23	.71	2.61	.55	2.92	.63
8	3.90	.67	3.13	.52	3.52	.60
9	4.61	.71	3.64	.51	4.13	.61

	Feed consumption per broiler		Feed conversion*	
Week	Weekly	Cumulative	Weekly	Cumulative
1	.16	.16	1.23	1.23
2	.36	.52	1.49	1.38
3	.60	1.12	1.68	1.53
4	.82	1.94	1.94	1.67
5	1.01	2.95	2.01	1.79
6	1.28	4.23	2.14	1.87
7	1.44	5.67	2.35	1.95
8	1.64	7.31	2.77	2.10
9	1.78	9.09	2.91	2.23

* Pounds of feed required to produce 1 pound of live weight.

Water

Water is the most important nutrient. One of its primary functions is to regulate body temperature. This is accomplished by evaporation through the air sacs, lungs, and, to some extent, the skin.

The consumption of water by the birds depends primarily on the ambient temperature and relative humidity, as demonstrated by the data in Tables 5 and 6 and Figure 27.

TABLE 5. Comparison of performance of single-comb White Leghorn laying hens under various temperature conditions

Ambient temp. (°F)	Feed consumed lb/hen/day	Water consumed lb/hen/day	Egg prod.	Hen weight	Droppings lb/hen/day	Moisture removed* (lb/hr) day	night
95	.120	.606	58.5	3.07	.377	.207	.112
65	.220	.400	62.5	3.54	.342	.150	.077
84	.170	.460	65.0	3.11	.308	.159	.114
65	.220	.393	78.0	3.49	.344	.138	.066
73	.192	.386	67.0	3.11	.304	.134	.075
65	.220	.400	67.0	3.49	.336	.125	.079
64	.220	.420	63.3	3.38	.341	.134	.076
65	.186	.373	67.5	3.33	.346	.099	.045
56	.220	.507	62.0	3.68	.418	.170	.087
65	.220	.384	62.0	3.52	.336	.123	.064
47	.240	.470	58.6	3.77	.422	.118	.073
65	.192	.362	60.0	3.60	.329	.111	.046

*Ventilation rate of 0.93 to 1.0 cfm/hen/hr.

TABLE 6. Constants for determining water consumption, fecal and water elimination in relation to feed consumption

	Ambient temperature			
	20-40 F	40-60 F	60-80 F	90-100 F
Water to feed ratio	1.5-1.7	1.7-2.0	2.0-2.5	2.5-5.0
Water plus feed to feces ratio	1.7	1.7*	1.8*	1.9*
Percent water content of feces	75	75	77	80
Percent water content of eggs	65	65	65	65
Size, ounces per dozen	24	24	24	24
Percent free, hygroscopic and metabolizable water in feed	54	54	54	54
Approx. heat of vaporization (BTU/lb)	1100	1100	1100	1100
Ratio of respired water to water input				
S. C. White Leghorn hens :	0.30-0.33	0.33-0.40	0.40-0.45	0.45-0.55
Rhode Island Red hens :	0.22-0.35	0.35	0.35-0.42	0.42-0.55
New Hamp. and Cornish hens:	0.25	0.25-0.35	---	---

* For White Leghorns add 0.30 to these values.

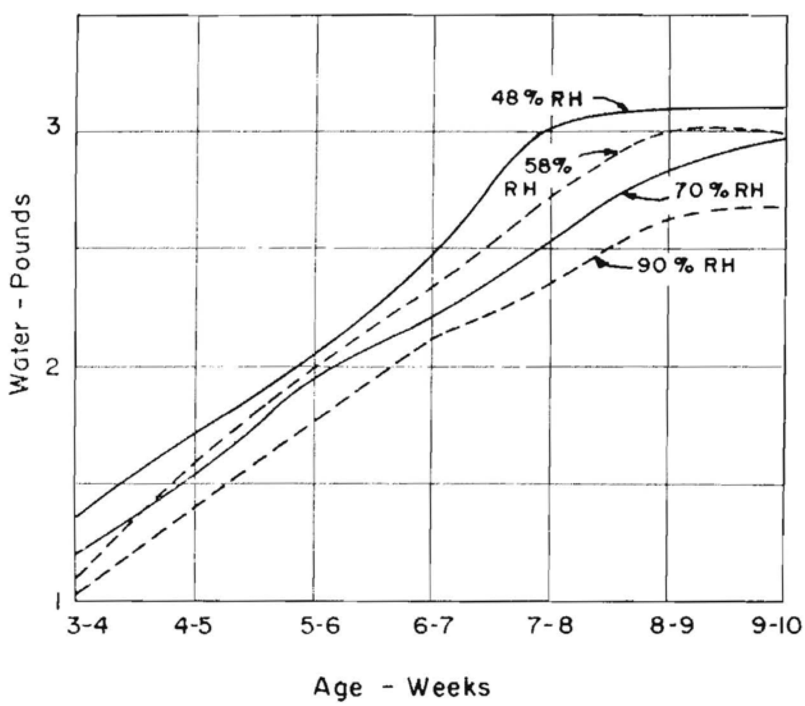


Figure 27. Effect of relative humidity on water consumption, in pounds per bird per week, at a constant temperature of 70 F.

Table 7 shows the amount of water present in air at various temperatures and humidities. Note that, at 70 F and 80 percent relative humidity, there are 88 grains of water per pound of air. At the same humidity but at 90 F, there are 172 grains of water per pound of air.

TABLE 7. The amount of moisture in a pound of air at various temperatures and humidities

	Percent relative humidity					
Air temperature	90	80	70	60	50	40
°F	------ Grains* water/lb. air --------					
40	33	29	25	22	18	14
50	48	43	37	32	27	21
60	69	62	54	46	38	31
70	100	88	77	66	55	44
80	140	124	108	92	77	61
90	195	172	150	127	106	84

* 7000 grains = 1 pound

Formulating rations

Balancing poultry rations is largely a matter of correcting the nutritional deficiencies of the feed ingredients that are used as energy sources (grains, fats, cassava, etc.). Feed ingredients differ in chemical composition and the nutrients contained in them. It is therefore necessary to know the nutrient requirements of chickens at different ages and according to utility of the chickens (Tables 8, 8A and 8B). It is also necessary to know which ingredients provide the best source of the required nutrients (Appendix A).

In general, chicks up to 4 or 8 weeks of age are fed a starter ration containing 20-22 percent crude protein. From 4 or 8 weeks of age and until they are 18 weeks old, the pullets are fed a grower ration containing about 17 percent crude protein. Thereafter, a layer ration containing 15-17 percent crude protein is fed.

TABLE 8. Nutrient requirements of chickens[1]
(In percentage or amount per kilogram of feed)

Nutrient	Starting chickens 0-8 wks	Growing chickens 8-18 wks	Laying hens	Breeding hens
Total protein, %	20	16	15	15
Vitamins				
Vitamin A activity (U.S.P. units)[2]	2,000	2,000	4,000	4,000
Vitamin D (ICU)	200	200	500	500
Vitamin E[3]	--	--	--	--
Vitamin K_1, mg	0.53	?	?	?
Thiamine, mg	1.8	?	?	0.8
Riboflavin, mg	3.6	1.8	2.2	3.8
Pantothenic acid, mg	10	10	2.2	10
Niacin, mg	27	11	?	?
Pyridoxine, mg	3	?	3	4.5
Biotin, mg	0.09	?	?	0.15
Choline, mg	1,300	?	?	?
Folacin, mg	1.2	?	0.25	0.35
Vitamin B_{12}, mg	0.009	?	?	0.003
Minerals				
Calcium, %	1.0	1.0	2.75[4]	2.75[4]
Phosphorus, %[5]	0.7	0.6	0.6	0.6
Sodium, %[6]	0.15	0.15	0.15	0.15
Potassium, %	0.2	0.16	?	?
Manganese, mg	55	?	?	33
Iodine, mg	0.35	0.35	0.30	0.30
Magnesium, mg	500	?	?	?
Iron, mg	40	?	?	?
Copper, mg	4	?	?	?
Zinc, mg	35	?	?	?

1 These figures are estimates of requirements and include no margins of safety.
2 May be vitamin A or pro-vitamin A.
3 Requirements for vitamin E vary so much, depending on the nature of the diet, that it seemed inadvisable to include figures in this table.
4 This amount of calcium need not be incorporated in the mixed feed, inasmuch as calcium supplements fed free-choice are considered as part of the ration.
5 At least 0.5% of the total feed of starting chickens should be inorganic phosphorus. All the phosphorus of non-plant-feed ingredients is considered to be inorganic. Approximately 30% of the phosphorus of plant products is non-Phytin phosphorus and may be considered as part of the inorganic phosphorus required. A portion of the requirements of growing chickens and laying and breeding hens must also be supplied in inorganic form. For birds in these categories the requirement for inorganic phosphorus is lower and not as well defined as for starting chickens.
6 Equivalent to 0.37% of sodium chloride.

TABLE 8A. Daily nutrient requirements per animal
(S. C. White Leghorns or similar breeds)

	Growing animal						Mature animal		
							Maintenance	Laying (60% Production)	Breeding (60% Production)
Body weight, g	250	500	750	1,000	1,250	1,500	1,800	1,800	1,800
Total daily feed, g	27	45	57	65	79	84	70	110	110
Crude protein, g	5.4	9	10.1	10.4	12.6	13.4	?	16.5	16.5
Calcium, g	0.27	0.45	0.57	0.65	0.79	0.84	?	3	3
Phosphorus, g	0.19	0.31	0.40	0.39	0.47	0.50	?	0.66	0.66
Sodium, g	0.040	0.067	0.085	0.097	0.119	0.126	?	0.165	0.165
Potassium, g	0.054	0.090	0.114	0.103	0.127	0.134	?	?	?
Magnesium, mg	13	22	28	?	?	?	?	?	?
Manganese, mg	1.4	2.4	3.1	?	?	?	?	?	3.6
Iodine, mg	0.009	0.015	0.020	0.023	0.028	0.029	?	0.033	0.033
Vitamin A, U.S.P. Units	54	90	114	130	158	168	?	440	440
Vitamin D, ICU	5.4	9	11.4	13	15.8	16.8	?	55	55
Thiamine, mg	0.048	0.081	0.103	?	?	?	?	?	0.088
Riboflavin, mg	0.096	0.162	0.206	0.117	0.142	0.151	?	0.242	0.420
Pantothenic acid, mg	0.27	0.45	0.57	0.65	0.79	0.84	?	0.242	1.10
Niacin, mg	0.73	1.21	1.54	0.71	0.87	0.92	?	?	?
Pyridoxine, mg	0.081	0.13	0.17	?	?	?	?	0.33	0.49
Biotin, mg	0.0024	0.0040	0.0051	?	?	?	?	?	0.016
Choline, mg	35	58	74	?	?	?	?	?	?
Folacin, mg	0.032	0.054	0.068	?	?	?	?	0.027	0.038
Vitamin B_{12}, mg	0.00024	0.00040	0.00051	?	?	?	?	?	0.00033

TABLE 8B. Daily nutrient requirements per animal
(Chickens of the heavy breeds)

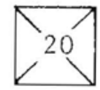
	Growing animal					Mature animal		
						Maintenance	Laying 60% Production	Breeding
Body weight, g	250	500	750	1,000	1,500	2,500	2,500	2,500
Total daily feed, g	35	57	73	84	100	87	125	125
Crude protein, g	7	11	15	17	20	?	18.7	18.7
Calcium, g	0.35	0.57	0.73	0.84	1	?	3.44	3.44
Phosphorus, g	0.24	0.40	0.51	0.59	0.70	?	0.75	0.75
Sodium, g	0.052	0.085	0.10	0.12	0.15	?	0.19	0.19
Potassium, g	0.070	0.114	0.14	0.17	0.20	?	?	?
Magnesium, mg	17	28	36	42	50	?	?	?
Manganese, mg	1.9	3.1	4	4.6	5.5	?	?	4.1
Iodine, mg	0.011	0.020	0.025	0.029	0.035	?	0.037	0.037
Vitamin A, U.S.P. Units	70	114	146	168	200	?	500	500
Vitamin D, ICU	7	11.4	14.6	16.8	20	?	62	62
Thiamine, mg	0.063	0.10	0.13	0.15	0.18	?	?	0.10
Riboflavin, mg	0.12	0.20	0.26	0.30	0.36	?	0.27	0.48
Pantothenic acid, mg	0.35	0.57	0.73	0.84	1	?	0.27	1.25
Niacin, mg	0.95	1.53	1.97	2.3	2.7	?	?	?
Pyridoxine, mg	0.10	0.17	0.22	0.25	0.30	?	0.37	0.56
Biotin, mg	0.0031	0.0051	0.0066	0.0076	0.0090	?	?	0.018
Choline, mg	45	74	95	109	130	?	?	?
Folacin, mg	0.042	0.068	0.088	0.100	0.120	?	0.031	0.043
Vitamin B_{12}, mg	0.00032	0.00051	0.00066	0.00076	0.00090	?	?	0.00037

The following are examples of rations formulated by using the "Dairyman's Square" to determine the amount of energy and protein ingredients to use for a mixture containing a certain protein content.

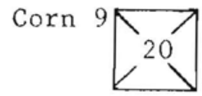
Example I: Compute a mixture containing 20 percent protein from corn containing approximately 9 percent protein and a commercial supplement containing 40 percent protein.

Step 1. Draw a square.

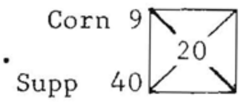
Step 2. In the center of the square, put the protein content (20%) desired in the final mixture.



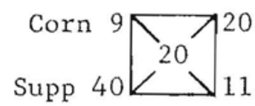
Step 3. At the upper left hand corner of the square, write "corn" and its protein content (9%).



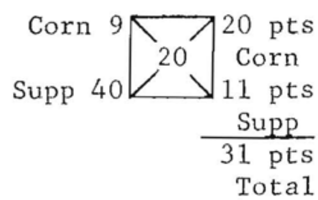
Step 4. At the lower left hand corner, write "supplement" and its protein content (40%).



Step 5. Subtract diagonally across the square (the smaller from the larger) and enter the results at the corners on the right hand side (20 - 9 = 11; 40 - 20 = 20).



Step 6. The number at the upper right hand corner gives the parts of corn, and the number at lower right hand corner gives the parts of supplement needed to make a mixture with 20 percent protein. Thus 20 parts of corn mixed with 11 parts of supplement gives 31 parts of feed with 20 percent protein.



Step 7. To convert this to a percentage basis, divide 20 by 31 and multiply the result by 100. The result, 64.5 percent, indicates the amount of corn that will be used in the ration. The supplement would represent 35.5 percent (100 - 64.5 = 35.5). Thus in a 100-pound 20% mix, there would be 64.5 pounds of corn and 35.5 pounds of supplement.

$$\% \text{ Corn} = \frac{20}{31} \times 100\% = 64.5\%$$

$$\% \text{ Supplement} = \frac{11}{31} \times 100\% = 35.5\% \text{ or } 100\% - 64.5\% = 35.5\%$$

The above is the simplest way of computing and balancing a ration. Commercial supplements will contain sufficient levels of protein, minerals, and vitamins so that, when mixed with the energy source (in this example, corn) according to recommendations, a complete ration will be obtained that will adequately meet the animal's nutrient requirements.

When a ration must be computed using basic feed ingredients, the procedure becomes a little more involved. In this situation, we must be concerned about not only the correct protein level. We must also make sure that adequate levels of minerals (primarily calcium and phosphorus) and vitamins are present in the final mixture. Certain guides can be used to help determine the levels of feed ingredients to use. Most poultry rations will require a standard addition of 0.5 percent salt (trace mineralized salt is preferred). When only protein sources of plant origin are used, 1 to 3 percent tricalcium phosphate or steamed bone meal must be added. If vitamin premixes are available, then 0.25 to 0.50 percent will normally be added to the complete ration to ensure adequate vitamin levels.

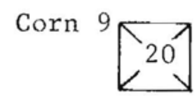
Example II: Compute a mixture containing 20 percent protein from corn containing 9 percent protein and soybean oil meal (S.O.M.) containing 44 percent protein. Since this mixture is composed of a single energy source and a single protein source of plant origin, it will be necessary to add sources of calcium and phosphorus as well as salt. A vitamin premix should be added if available.

Step 1. Determine what combination of the two main ingredients is needed to establish the correct protein level.

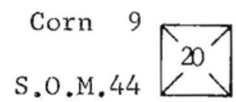
As before, draw a square.

Step 2. In the center of the square, put the desired protein content (20%) of the final mix.

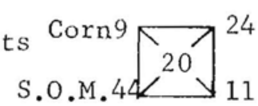
Step 3. At the upper left hand corner of the square, write "corn" and its protein content (9%).



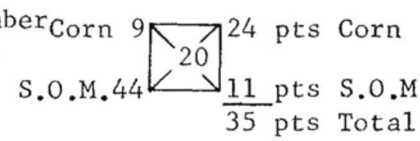
Step 4. At the lower left hand corner write "soybean oil meal" and its protein content (44%).



Step 5. Subtract diagonally across the square (the smaller from the larger) and enter the results at the corners on the right hand side (20 - 9 = 11; 44 - 20 = 24).



Step 6. The number at the upper right hand corner gives the parts of corn (24) and the number at the lower right hand corner gives the parts of soybean oil meal (11) needed to make a mixture with 20% protein.



Step 7. To convert this to a percentage basis, divide 24 by 35 and multiply the result by 100. The result (68.6%) indicates the amount of corn in the ration. Thus 68.6 pounds of corn mixed with 31.4 pounds of soybean oil meal will provide a 20 percent protein mix. This meets the protein requirements (it assumes that the amino acid requirements are also met).

$$\% \text{ Corn} = \frac{24}{35} \times 100 = 68.6\%$$

$$\% \text{ S.O.M.} = \frac{11}{35} \times 100 = 31.4\% \text{ or } 100\% - 68.6\% = 31.4\%$$

Step 8. The next step is to calculate how much calcium and phosphorus the corn and soybean oil meal contribute. Then it is a matter of making up the difference between these amounts and the recommended levels of these nutrients. Table 8 indicates that a chick from 0 to 8 weeks of age requires 1.0 percent calcium and 0.7 percent phosphorus in the ration. The feed composition table (Appendix A) shows that corn contains 0.02 percent calcium and 0.33 percent phosphorus. Soybean oil meal contains 0.32 percent calcium and 0.67 percent phosphorus. To calculate the amount of calcium and phosphorus contributed by each ingredient, a worksheet similar to that shown in Table 9 can be used for the necessary calculations.

To calculate the amount of calcium and phosphorus supplied by corn:

a. Multiply 0.02% calcium in corn by 68.6 pounds (0.02% x 68.6 = 0.014 lb.).
b. Multiply 0.33% phosphorus in corn by 68.6 pounds (0.33% x 68.6 = 0.23 lb.).

To calculate the amount of calcium and phosphorus in the soybean oil meal:

a. Multiply 0.32% calcium in S.O.M. by 31.4 pounds (0.32% x 31.4 = 0.10 lb.).
b. Multiply 0.67% phoshporus in S.O.M. by 31.4 pounds (0.67% x 31.4 = 0.21 lb.).

The total amount of calcium and phosphorus supplied in the ration then is 0.114 pound calcium (0.014 + 0.100) and 0.44 pound phosphorus (0.23 + 0.21). Since the calcium and phosphorus requirements are 1.0 and 0.7 pound per 100 pounds of ration, respectively, this means that 0.886 of calcium (1.0 - 0.114) and 0.260 pound phosphorus (0.7 - 0.440) must be added to the ration.

A calcium-phosphorus source such as tricalcium phosphate may be used. This compound contains 32 percent calcium and 16 percent phosphorus. By adding 3 pounds of tricalcium phosphate to the ration, 0.96 pound of calcium and 0.48 pound of phosphorus would be added. The ration will then contain 1.07 pounds of calcium (0.96 + 0.114) and 0.92 pound of phosphorus (0.48 + 0.44).

The salt requirement is 0.05 percent of the ration. This can be met by adding ½ pound of trace mineralized salt, which will also satisfy the trace mineral requirements.

Similar procedures as outlined above can be used to establish levels of vitamins and other nutrients in the ration to compare with the requirements.

TABLE 9. Worksheet for sample ration formulation (Example II)

Ingredient	Calculated analysis				
	Amount lb.	Protein lb.	Calcium lb.	Phosphorus lb.	Salt lb.
Corn	68.6	6.17	0.014	0.23	--
Soybean oil meal	31.4	13.81	0.100	0.21	--
Subtotal	100.0	19.98	0.114	0.44	--
Tricalcium phosphate	3.0	--	0.96	0.48	--
Salt (trace mineralized)	0.5	--	--	--	0.5
Grand total	103.5	19.98	1.074	0.92	0.5
Nutritive requirement		20.0	1.0	0.70	0.5

Example III. Formulate a layer ration containing 15 percent protein using more than two ingredients. The procedure is similar to Examples I and II. The only requirement is that all but the two largest quantities must be fixed. In this example, corn again will be used as the source of energy and soybean oil meal as the source of protein. We will also use 10 pounds cassava meal, 5 pounds tuna meal, and 10 pounds coconut meal. It should be noted, however, that balancing the calcium and phosphorus contents of a ration becomes a problem when a limited source of animal protein feedstuffs is used. It is therefore desirable to use more than one source of animal protein, if available. In formulating this ration, you should allow about 6 percent for calcium and phosphorus sources.

Using the feed composition tables, note that the cassava meal is comprised of 1.4 percent protein, tuna meal of 55 percent protein, and coconut meal of 20 percent protein.

By multiplying 10 pounds by 1.4%, we find that cassava meal will contribute 0.14 pound of protein.

By multiplying 5 pounds by 55%, we find that tuna meal will contribute 2.75 pounds of protein.

By multiplying 10 pounds by 20%, we find that coconut meal will contribute 2.0 pounds of protein.

These ingredients at these levels will then add 4.89 pounds (0.14 + 2.75 + 2.0) of protein to the ration. Therefore, we need 10.11 percent additional protein from the corn and soybean oil meal. However, these two ingredients now constitute 69 percent of the ration (100 - 31, including the allowance of 6 percent for the calcium and phosphorus sources), so we divide 10.11 by 69 and multiply by 100, which is equal to 14.65 or 14.7 and proceed as before.

Step 1. Draw a square.

Step 2. In the center of the square, put the protein content (14.7) desired.

14.7

Step 3. At the upper left hand corner of the square write "corn" and its protein content (9%).

Corn 9 14.7

Step 4. At the lower left hand corner, write S.O.M. and its protein content (44%).

Corn 9 14.7
S.O.M.44

Step 5. Subtract diagonally across the square (the smaller from the larger) and enter the results at the corners on the right hand side.

Corn 9 29.3
14.7
S.O.M.44 5.7

Step 6. The number at the upper right hand corner gives the parts of corn (29.3) and the number at the lower right hand corner gives the parts of S.O.M. needed to make a mixture of 14.7% protein.

Corn 9 29.3 pts corn
14.7
S.O.M. 44 5.7 pts S.O.M.
35 pts total

Step 7. To convert these figures to a percentage basis, divide 29.3 by 35 and multiply by 100. The result (83.7) is then multiplied by 69% to get 57.8. This means that of the 69 pounds, 57.8 pounds would be corn and the difference (69 - 57.8) of 11.2 would be S.O.M.

$$\frac{29.3}{35} \times 100 \times 69\% = 57.8 \text{ lb. corn}$$

$$69 - 57.8 = 11.2 \text{ lb. S.O.M.}$$

Thus, in addition to the mineral sources, this ration will be comprised of:

Corn	57.8	pounds
S.O.M.	11.2	"
Cassava meal	10.0	"
Coconut meal	10.0	"
Tuna meal	5.0	"

These ingredients will provide 15.02 percent protein, thus meeting protein requirements (assuming that the amino acid requirements are also met). However, it has been found that one of the essential amino acids, methionine, will be limiting when using tuna meal and cassava meal. It is therefore necessary to incorporate this acid in synthetic form (DL methionine) at the rate of 0.15 to 0.20%.

Step 8. Adjusting the mineral content (calcium and phosphorus) is the next step. Using the feed composition tables, we find that the above ingredients supply 0.328 pound of calcium and 0.492 pound of phosphorus, which do not meet the requirements for laying hens. A source of calcium and phosphorus, such as tricalcium phosphate, and a source of calcium only, such as oystershell, could be used. Adding 1 pound of tricalcium phosphate and 5 pounds of ground oystershell will contribute 2.220 pounds of calcium and 0.160 pounds of phosphorus. These additions will bring the calcium content up to 2.548 (0.328 + 2.220) and the phosphorus content up to 0.652 (0.492 + 0.160). Although this meets the phosphorus requirements, it does not meet the calcium requirements. This is not too critical because you can provide hen-size oystershell free choice (in a separate hopper from the one used for the feed).

The addition of trace mineralized salt is also necessary (0.5 pound). A sample worksheet for the ration described in Example III is presented in Table 10.

Table 10. Worksheet for sample ration formulation (Example III)

	Calculated analysis				
Ingedients	Amount lb.	Protein lb.	Calcium lb.	Phosphorus lb.	Salt lb.
Corn	57.8	5.20	0.012	0.191	--
Soybean oil meal	11.2	4.93	0.036	0.075	--
Cassava meal	10.0	0.14	0.013	0.015	--
Tuna meal	5.0	2.75	0.250	0.150	--
Coconut meal	10.0	2.00	0.017	0.061	--
Subtotal	94.0	15.02	0.328	0.492	--
Tricalcium phosphate	1.0	--	0.320	0.160	--
Ground oystershell	5.0	--	1.900	--	--
Trace mineralized salt	0.5	--	--	--	0.5
Grand total	100.5	15.02	2.548	0.652	0.5
Nutrient requirement	--	15.0	2.75*	0.6	0.5

* See footnote 4 in Table 8.

These examples are illustrations of how to formulate complete rations, starting with an energy source and adding sources of protein, minerals, and vitamins. These complete rations will generally meet the bird's nutrient requirements. Complete rations should not be diluted with any other feed ingredients after the initial formulation, except when feeding oystershell free choice in Example III. Otherwise, it is possible that the nutrient requirements will not be met.

Care of feed in storage

After the ration is formulated and mixed, or if you buy mixed feeds, it is always desirable to store them in a cool and dry atmosphere, as high temperatures or even prolonged exposure to air may destroy the vitamins and reduce their strength. Chronic vitamin deficiency symptoms are difficult to detect, but symptoms of acute deficiencies are readily detected (Figures 28 and 29).

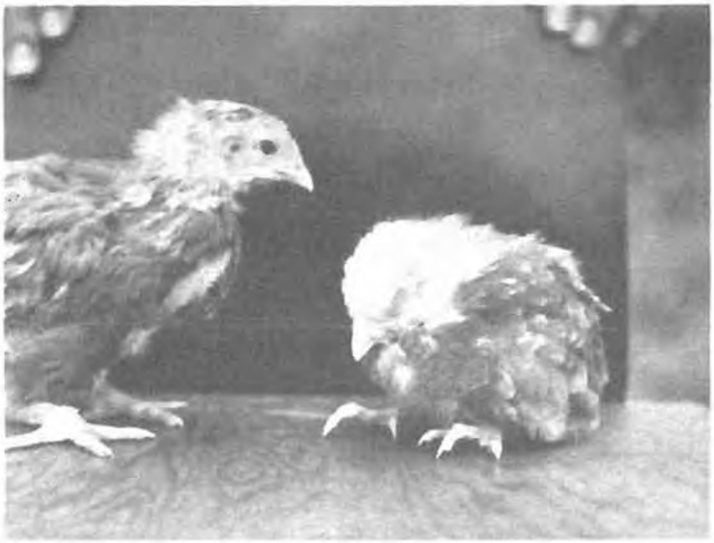


Figure 28. Two chicks of the same age and breed. The one on the left was fed a balanced ration. The chick on the right was also fed a balanced ration except for a deficiency in Vitamin A. Note its unthrifty condition and ruffled feathers.

Figure 29. A chick showing phosphorus deficiency. It has lost the use of both legs. Phosphorus is essential in most metabolic processes, such as in the liberation of energy, enzyme activity, and the functioning of vitamins.

DISEASES AND PARASITES

Diseases and parasite infestations constitute a major problem wherever chickens are raised. In a commercial operation, they are the greatest deterrents to greater profits. Any person raising chickens should constantly watch for signs of diseases and parasite infestations in the flock. Unless he is an experienced poultryman, however, he may find it difficult to detect disease symptoms. A qualified veterinarian in your area could help detect diseases and recommend treatment.

Keep in mind, however, that prevention is always easier and cheaper than treatment, so you should:

1. Keep the chickenhouse and the immediate area around it clean and dry.

2. Get rid of rats and mice. They spread diseases and consume large amounts of feed.

3. Isolate sick birds. Keep them away from the healthy ones in separate pens and houses. Better yet, kill the sick birds immediately and either burn or bury them. You should also burn or bury dead birds found in the flock.

4. Give your birds clean, cool water daily.

5. Give fresh feed daily to your birds. Do not allow the trough to become caked with old feed. Old feed is less nutritious and could support the growth of fungi, which can infect your birds with serious consequences.

The following is some background information on common poultry diseases. Many of these diseases may not yet be prevalent in certain areas, but information on them has been included.

Fowl typhoid

Background: This septicemic disease is most common in chickens, but also is found in turkeys.

Cause: Bacteria of the Salmonella family.

Age affected: May attack birds of any age, but young, growing birds and adult birds are most susceptible.

Symptoms: Affected birds seem to waste away. They also show signs of weakness, drowsiness, yellowing diarrhea, and anemia. Sometimes death occurs before the symptoms show up.

Spread: "Carrier" birds often are brought into the flock when replacements are purchased; but, in such cases, the disease may not show up right away. It also can be spread by contaminated boots, clothes, feed, water, rodents, and wild birds. The causative organism can survive for 2 months in deep litter.

Prevention: Always buy replacements from suppliers or flocks that are known to be clean. Follow strict sanitation procedures.

Pullorum disease

Background: This disease is most prevalent in chickens, but turkeys may also be affected.

Cause: Bacteria of the Salmonella family.

Age affected: Birds of any age, but the disease causes greatest losses in young chicks and poults.

Symptoms: Adult birds often get the disease without showing any outward signs. Affected young birds, however, often die from the 4th to 11th day of life. Affected birds try to huddle together near a source of heat, stop eating, look sleepy, and may show a whitish diarrhea. Infected birds often have deposits of excreta around the vent.

Spread: The disease is spread by adult carrier birds that lay infected eggs. Once the eggs hatch, other chicks are rapidly infected by inhalation or ingestion of contaminated food or water. Adult birds also may become infected from contaminated droppings from other birds in the flock.

Prevention: Follow strict sanitation at all times. If the disease shows up, start with entirely new birds at next opportunity in order to eliminate unsuspected carriers. Buy replacements from clean, accredited hatcheries.

Fowl cholera

Background: This infectious disease can attack all types of domestic fowl. Some forms also attack animals and man.

Cause: Bacteria of the Pasteurella family.

Age affected: Principally a disease of young layers and adult birds.

Symptoms: Affected birds show watery diarrhea and difficulty in breathing. The disease usually produces high mortality and high sick rate. Death sometimes occurs before any other sign of disease is noticed. Bacteriological examinations usually are necessary to distinguish this disease from other conditions.

Spread: The disease usually is spread through contaminated feed and water and occasionally through inhalation. The organisms are carried in the droppings of infected birds. Dead birds are a source of infection for at least a month after death. Flies and ducks can also spread the disease. Birds that appear to have recovered may still carry the disease.

Prevention: Follow strict sanitation procedures and sound management practices at all times.

Chronic respiratory disease

Background: This serious infectious disease attacks both chickens and turkeys and is sometimes called CRD or air-sac infection. The disease attacks the upper and the lower respiratory tract as well as the air sacs.

Cause: Pleuropneumonia-like organisms (PPLO), complicated by *E. coli* and other secondary bacterial and viral organisms.

Age affected: All ages. In recent years, outbreaks have been more frequently observed in adult birds.

Symptoms: First sign is usually a mild or moderate cough. Unless secondary infections occur, mortality and sickness are usually low, except in broilers where death losses may be high. Egg production may fall off 10 to 20 percent.

Spread: Spreads very slowly unless birds are overcrowded. Sometimes the disease doesn't spread from one house to a nearby house for a long time. Infectious bronchitis often results in a CRD outbreak. Infected birds act as carriers for a long period; consequently, the infection eventually spreads to the entire flock and persists for many years. Causative organisms usually enter the bird through inhalation. Transmission through hatching eggs also has been known to occur.

Prevention: Follow strict sanitation and management practices at all times.

Infectious coryza

Background: This disease is often referred to simply as a "cold." It usually is associated with cold, damp weather and only attacks chickens.

Cause: Bacterium known as *Hemophilus gallinarum*.

Age affected: Any age, but most commonly seen in growing birds and young adults.

Symptoms: Usual signs of a "cold," including swollen sinuses, nasal discharge, and sneezing. Other complications, such as conjunctivitis, tracheitis, bronchitis, and air-sac infection, may also set in.

Spread: Mainly by direct contact or through the air. May be carried on contaminated feed sacks and equipment or on the shoes of caretakers. Recovered birds may act as carriers.

Prevention: Raise chicks away from older birds. Do not mix pullets and old hens. Provide dry, draft-free housing. Follow strict sanitation procedures at all times.

Infectious synovitis

Background: This disease also has been called infectious arthritis, enlarged hock condition, or infectious anemia. It attacks both chickens and turkeys and is an economically important disease of broilers.

Cause: Suspected large virus.

Age affected: Occurs most often in young birds, 4 to 10 weeks of age, but also can attack older birds.

Symptoms: Swollen hock joints and foot pads are among the first signs. Green droppings may appear during early stages of the disease. Many affected birds show very few signs of sickness. Death losses may be few, but the disease may leave birds crippled.

Spread: Spreads slowly through a flock. May be transmitted through eggs. Direct contact is necessary for infection.

Prevention: Follow strict sanitation procedures at all times.

Bluecomb

Background: In chickens, this disease also is known as pullet disease, avian monocytosis, summer disease, or housing disease. In turkeys, other names include nonspecific enteritis and mud fever. The disease occurs most often in summer or fall.

Cause: Possibly a virus.

Age affected: Most common in young birds, but older birds also can be affected.

Symptoms: Mortality and a sudden drop in egg production are the first signs. Affected birds show whitish, watery diarrhea and shrunken, shriveled shanks. Wattles and combs turn dark blue. There may be a partial molt, and eyes of affected birds may have sunken appearance.

Spread: Very little is known about the spread of this disease. It appears to be infectious, but often does not spread from pen to pen.

Prevention: Follow strict sanitation procedures at all times.

Newcastle disease

Background: The disease also is known as avian pneumoencephalitis and attacks both chickens and turkeys.

Cause: Virus.

Age affected: Birds of any age.

Symptoms: First signs are usually respiratory problems such as gasping, coughing and sneezing, and hoarse chirping. Egg production may stop completely within a few days of the first symptoms. Feed consumption drops rapidly and birds become inactive. In later stages, nervous symptoms usually appear, including paralysis and muscular tremors. Death losses may be high in young birds.

Spread: The virus, which is unusually resistant to heat, can be spread directly and indirectly. Excretions from affected birds carry the virus. Recovered birds seldom act as carriers for more than 3 or 4 weeks. Actual spread of the disease can occur through improper carcass disposal, undetected outbreaks in hatcheries, wild birds, air movement around infected birds, and contaminated equipment.

Prevention: Purchase replacements that are known to come from a clean source. Follow strict sanitation procedures and recommended vaccination programs.

Fowl pox

Background: Both chickens and turkeys can be affected by this disease. Outbreaks are most common when young birds are put in the laying house.

Cause: Virus.

Age affected: Young birds are most susceptible, but the disease can attack birds of all ages.

Symptoms: Wartlike nodules appear on comb, wattles, and eyelids. Cankers may develop in the upper-digestive and respiratory tracts. Lesions also may appear on the legs. Egg production may fall off and birds may go into a partial molt.

Spread: The virus enters the bird only through wounds and abrasions on the head or in the mouth. The disease usually spreads very slowly and may persist on a farm for many years. Mosquitoes carry the virus and may be infective for as long as 2 months.

Prevention: Do not overcrowd birds. Follow strict sanitation procedures at all times. Eliminate all possible causes of wounds and injuries. Follow recommended vaccination programs.

Infectious laryngotracheitis

Background: This highly contagious disease primarily attacks chickens.

Cause: Virus.

Age affected: Mostly growing and adult birds, although young birds also can be affected.

Symptoms: Gasping, coughing, and blood-stained tracheal discharge are common signs. Beaks may become blood-stained. Affected birds may lose their appetites and become inactive. Death losses from suffocation are common.

Spread: The disease normally enters through the respiratory tract, with an incubation period after exposure of 6 to 12 days. Recovered birds may act as carriers for as long as a year or more.

Prevention: Follow strict sanitation procedures at all times. Use a vaccination program recommended by your veterinarian, poultry serviceman, or local Poultry Diagnostic Laboratory, if the disease has been present on the farm.

Infectious bronchitis

Background: This disease is one of the most contagious conditions known to affect poultry. It is of primary importance in chickens.

Cause: Virus.

Age affected: Found most frequently in adult chickens, although younger birds also may be affected.

Symptoms: The most common signs are nasal discharge, gasping, and coughing. The causative organism is present in the nasal discharge and droppings of affected birds. Also may spread through contaminated feed bags and equipment. The disease spreads from house to house. Recovered birds may spread the disease for as long as 5 weeks.

Prevention: Follow strict sanitation procedures at all times. Use only recommended vaccination programs.

Avian leukosis

The diseases that make up the avian leukosis complex are transmissible virus diseases of birds characterized by tumor formations. The diseases are widespread and have been the most devastating of those affecting mature laying chickens, and in recent years have become increasingly significant as a cause of losses in broilers and growing birds.

Of the separate and distinct diseases which form the complex, lymphoid leukosis and Marek's disease produce the most losses.

Lymphoid leukosis (L.L.)

Characteristically, lymphoid leukosis is a disease of adult chickens;

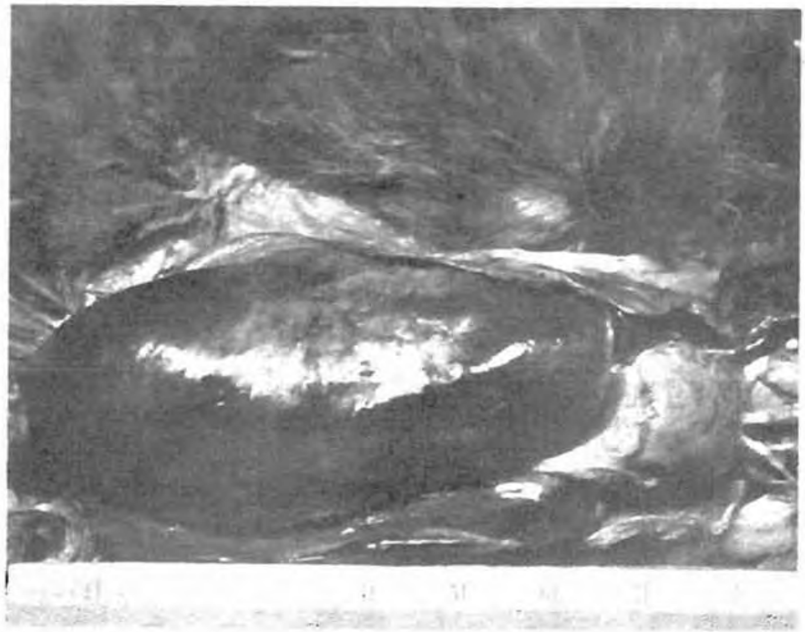


Figure 30. This photograph illustrates the size of the liver caused by visceral leukosis (big liver disease).

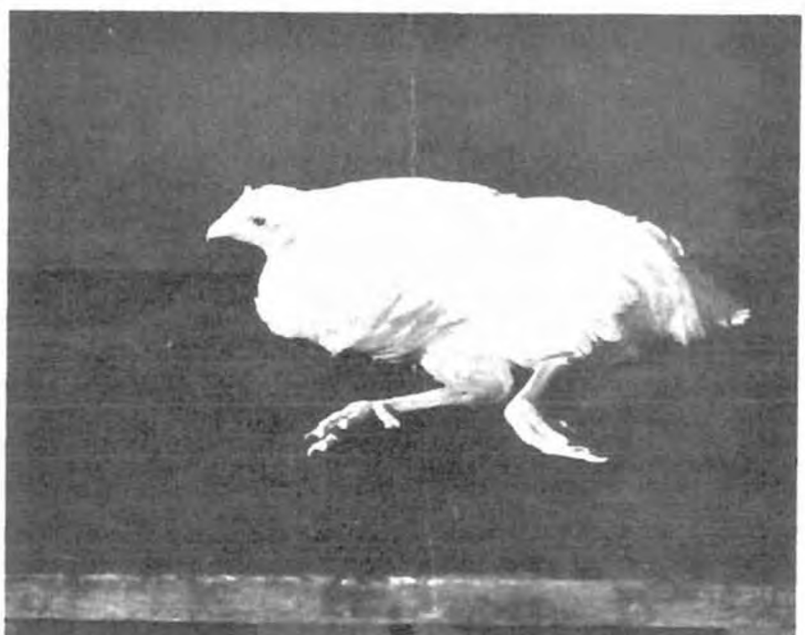


Figure 31. This bird is afflicted with neural leukosis (fowl paralysis or leg paralysis).

however, the disease appears to be of increasing importance in turkeys and other species, e.g., pheasant. Although the virus of lymphoid leukosis may produce various responses (e.g., blood forms--erythroblastosis and myeloblastosis; bone forms--osteopetrosis), the lymphoid tumor response is the most common.

Cause and transmission: Lymphoid leukosis is caused by a group of enveloped RNA viruses which closely resemble those of the myxovirus group. The disease is transmitted in a number of ways. The agent is eliminated naturally from the body of the infected bird via eggs and feces. The virus may be transmitted mechanically from infected birds to susceptibles by blood-sucking parasites or by man in such procedures as fowl pox vacnation. Most infections are acquired during the first few weeks of life. This suggests that most flocks acquire the disease by egg transmission or by direct or indirect contact with older infected birds during the early brooding period.

Manifestations of disease: Lymphoid leukosis is characterized by the formation of lymphoid tumors, particularly in the liver and spleen. Affected birds may die without preliminary symptoms, but the disease is usually chronic in nature with affected birds showing loss of appetite, progressive emaciation and diarrhea.

Osteopetrosis is the bone form of the disease. Until recently it was thought to be a disease primarily of older birds, particularly males; however, it is now known to be quite common in young chickens and is one of the more serious causes of broiler condemnations. The disease is characterized by a thickening and deformation of bone, the long bones in particular. This frequently results in lameness and faulty body conformation.

Blood forms of L.L. are diagnosed infrequently.

Treatment and prevention: There is no treatment for lymphoid leukosis. Although the disease cannot be prevented completely, certain steps can be taken to help control the level of infection in a flock. Some of these are listed below.

Buy resistant strains of birds. Most reputable breeders have invested a great deal of time and money breeding for L.L. resistance.

Brood in isolation. Most L.L. is acquired early (under 6 weeks of age). If replacement birds are brooded in strict isolation, contact transmission (direct and indirect) from adult carriers will be minimal.

Keep incubator sanitary.

Control blood-sucking parasites.

Do not use gimmicks in disease control (e.g., explosive outbreaks of L.L. have occurred following the indiscriminate use of turkey blood in "control" programs for Marek's disease).

Marek's disease (M.D.)

Marek's disease is characteristically a disease of young chickens; however, it is commonly seen in adult birds. In contrast to L.L., the tumor response of M.D. is limited to that of the lymphoid type. However, the response may be much more diverse in location than that usually seen in lymphoid leukosis.

Cause and transmission: Marek's disease is caused by a virus belonging to the herpes virus group. Much is unknown about the transmission of the virus; however, it appears that the virus is concentrated in the feather follicles of affected birds and is shed in dander. The virus apparently has a long survival time in dander, and viable virus may be demonstrated in depopulated houses months after infected birds have been removed. The usual mode of transmission is by aerosols containing infected dander and dust. As is the case with L.L., young birds are most susceptible to infection with M.D.; however, since the incubation period of M.D. is short, clinical disease can appear much earlier than with lymphoid leukosis.

Manifestations of disease: Marek's disease may produce a variety of lymphoid clinical responses: acute visceral, neural, ocular and skin, or, as is commonly the case, the combination of these responses.

The visceral type may be characterized by widespread involvement. The lesions are most commonly associated with the gonads (testes and ovaries), liver, spleen and kidney; however, other organs, such as the lungs, heart and musculature, are commonly involved. The disease is often acute, with apparently healthy birds dying very rapidly and having massive internal tumors. The disease may appear in broiler-age birds and be a significant cause of death loss and condemnations. More commonly the disease produces the most severe losses in replacement pullets near or at the onset of production. At this time, the disorder is seen frequently in birds with acute coccidiosis, leading some to suspect that there is a relationship between the two diseases. At present, the only relationship considered is that a bird with coccidiosis or M.D. is more susceptible to the other disease.

The neural type of Marek's disease is the classical type. Neural leukosis was the first disease known as M.D. before the etiologic relationships of the various diseases in the leukosis complex were established. Neural leukosis is characterized by a progressive paralysis of the wings, legs and neck. Loss of body weight, anemia, labored respiration and diarrhea are common symptoms. When affected birds are autopsied, lesions, if observed in uncomplicated cases, are confined to the nerve trunk and plexuses innervating the paralyzed extremities. Affected nerve tissue is swollen as a result of accumulation of lymphocytes and tissue fluids.

Ocular leukosis (gray eye) is responsible for much of the blindness in chickens. This type of M.D. usually is seen in early maturity. Morbidity and subsequent mortality are usually low but in some instances approach 15 to 25 percent. Ocular leukosis is characterized by spotty pigmentation or diffuse graying of the iris of the eye caused from lymphocytic infiltrations. The pupil develops an irregular shape and fails to accommodate light. Emaciation, diarrhea and death usually follow because of partial to complete blindness.

Skin leukosis is the form of M.D. that produces the most severe losses in broilers. Losses are more commonly due to condemnation at processing time. The disorder is characterized by enlargement of the feather follicles due to accumulations of lymphocytes. As has been stated, most infective virus is produced in the regions of the feather follicle and is shed with dander.

Course of disease: Acute M.D. can be extremely rapid in its course, producing mortality in apparently healthy birds. However, it has been demonstrated that the lesions of M.D., particularly of skin leukosis, may regress and clinically affected birds may make complete recovery.

Treatment and prevention: As with L.L., there is no treatment for Marek's disease and, until recently, there have been no effective preventive measures.

A vaccine is now available that appears to be extremely effective in the prevention of M.D. The vaccine is made with a herpes virus of turkeys (H.V.T.) that prevents the virus of M.D. from transforming cells to produce tumors. Although quite expensive when it became available initially, the vaccine has since been reduced in price and replacement pullets, breeders, and broiler chicks are now being vaccinated. The vaccine should be applied in strict accordance with the manufacturer's recommendations.

A program to control M.D., still in experimental stages, that may have merit in the future is the use of filtered air positive pressure (F.A.P.P.) housing to start broiler chicks. Chicks started in such a controlled environment can be maintained free of exposure to M.D. virus during the first few weeks of life. When transferred to conventional housing at an age of several weeks, the chickens may be exposed to M.D. virus, but the disease does not have sufficient time to develop before the birds are marketed.

Coccidiosis

Background: This disease develops from organisms naturally present in all chickens and turkeys.

Cause: A microscopic parasite in the protozoa class.

Age affected: All ages can be affected. Cecal or bloody coccidiosis occurs most often in chickens 5 to 7 weeks of age. Chronic forms of the disease are most common in older birds. Poults are more susceptible to the disease between 1 and 3 months of age.

Symptoms: Among the signs of the various forms of the disease are bloody droppings, high death losses, decreased feed consumption, droopy appearance, and weight losses. Many signs of the disease must be verified by laboratory tests.

Spread: The resistant stage of the causative organism (oocyst) is passed in the droppings and survives on the ground for long periods. Infection spreads when birds consume contaminated feed or water. Adult birds are a constant source of reinfestation.

Prevention: Raise young birds on ground that has not been exposed to older birds for at least a year. Follow strict sanitation procedures.

Blackhead

Background: This disease also is known as histomoniasis or infectious enterohepatitis. It is the most common and widespread disease of turkeys but also can attack chickens.

Cause: A microscopic parasite in the protozoa class.

Age affected: Birds of all ages, but heaviest death losses occur during the first 12 weeks of life.

Symptoms: Common signs include listlessness, drooping wings, and ruffled feathers. The head may take on a dark color. Affected birds may show yellowish diarrhea.

Spread: Eggs of certain harmless intestinal worms (cecal worms) can harbor the causative organism, carrying the disease in the droppings. These organisms may live on the ground for long periods, then infect other birds.

Prevention: Follow strict sanitation procedures at all times.

Aspergillosis

Background: This disease, also known as brooder pneumonia, mycotic pneumonia, or pneumomycosis, is a respiratory ailment of both chickens and turkeys.

Cause: Fungus.

Age affected: Most common in young birds.

Symptoms: Affected birds may have difficulty breathing. Gasping and nervous symptoms are common. Feed consumption may drop, but birds may drink more water than usual.

Spread: The causative organism is part of the common mold that grows on vegetables, straw and chaff. When birds scratch in such materials, they inhale the spores of the fungus. This fungus is most prevalent under warm, moist conditions.

Prevention: Do not expose birds to moldy litter or feed. Follow strict sanitation procedures at all times.

Thrush

Background: This disease also is known as brooder pneumonia, moniliasis, oidomyosis, sour crop, soor, or muguet.

Cause: Fungus.

Age affected: Young birds are most susceptible.

Symptoms: A slimy discharge may drool from the mouths of affected birds. Sometimes the only outward signs are depression and emaciation.

Spread: By contact with affected birds.

Prevention: Follow strict sanitation procedures at all times.

Bear in mind that the foregoing is not the complete list of diseases that affect chickens and turkeys. Information on other diseases as well as those mentioned here may be obtained from books on poultry husbandry, serviceman's manuals, and periodicals.

External parasites (lice and mites)

Many species of lice and mites infest poultry. However, only a few of these cause a severe problem.

Lice are flat, wingless, brownish yellow insects that move very quickly. They are the most prevalent external parasite of poultry. The most common lice of chickens are the common large louse (chicken body louse), the small body louse (shaft louse), the chicken head louse, and the wing louse.

Lice can be found by a careful examination of an infested bird under good lighting. The body louse can most often be seen around the vent. If the louse itself cannot be found, clusters of white eggs (nits) can be seen attached to the base of the feathers.

Lice spend their entire life cycle on the chicken. They have chewing, biting mouthparts. This type of mouth is ideal for eating cells of the skin and feathers which serve as food for the louse. The body louse can draw blood which it also uses for food. Lice cannot live long without a source of food.

Lice are a nuisance to chickens. Although it is very rare, heavy infestations of lice can cause death in young birds. Because lice cause constant and severe irritation of the skin, heavily infested birds are extremely restless. The birds do not eat or sleep normally. This may cause lowered egg production and poor weight gains.

Mites are much smaller than lice and are best seen with the aid of a microscope or magnifying glass. They vary considerably in body conformation and living habits.

The most common and widespread mite is the red or roost mite. The northern feather or fowl mite is probably the next most prevalent mite of chickens. The scaly leg mite, depluming mite, and air sac mite are not common but have caused problems for some poultrymen.

Low egg production and poor weight gains are typical results from heavy infestations of mites. Occasionally, deaths have been reported. Because most mites of birds use blood or tissue fluid (lymph) for food, anemia is a common symptom. The blood-sucking mites have been shown to be transmitters of diseases such as fowl cholera, Newcastle disease, and several types of encephalitis.

Mites can live in an empty house for many months without any apparent source of food. The red mite is a blood-sucking mite and uses large amounts of blood for food. It is actually gray but usually appears red when full of blood. It feeds only at night. During the day, it lodges in the cracks and crevices of the roosts and the house. To find the red mite, examine the birds at night or examine closely cracks, crevices, and undersides of roosts or perches.

The northern fowl mite resembles the red mite in appearance but it is somewhat smaller and ordinarily spends its entire life on the chicken. When infested birds are handled, the mites quickly crawl over the examiner's hands and arms. The mites or clusters of their eggs on the base of feathers can be seen by parting the feathers about the tail and the vent. These mites are vicious bloodsuckers. They also cause scabs to form on the skin.

Chiggers, bedbugs, fleas, ticks, flies, gnats, mosquitoes as well as some uncommon types of lice and mites may cause injury to poultry from time to time. If you suspect one of these, it is best to consult a person familiar with insects for identification and treatment.

Treatment

The common methods of treatment of chickens for lice and mites include sprays, dusts, and roost paints. In general, the methods that do not require individual handling of birds are preferred. Whatever method is chosen, it should be repeated at about 10-day intervals or as often as necessary. Malathion used at 1 ounce per gallon of water as a spray on the birds is very effective. If dusting of the litter is preferred, use 1 pound of Sevin dust per 40 square feet of litter. Lice and northern fowl mites can also be controlled by applying Sevin dust by means of a shaker can or handduster directly to the birds at the rate of 1 pound per 100 birds. If roost paint is preferred, use 2 ounces of Malathion per gallon of water.

NOTE: INSECTICIDES ARE POISONOUS TO MAN AS WELL AS POULTRY. READ THE LABELS ON THE CONTAINER CAREFULLY AND FOLLOW THE DIRECTIONS EXACTLY. DO NOT CONTAMINATE THE FEED, WATER, OR EGGS.

Internal parasites (worms)

The common internal parasites of chickens are large roundworm, cecal worm, capillaria worm, and several species of tapeworms. To become infested with worms, a chicken must first eat infective worm eggs or infective intermediate hosts, as in the case of tapeworms. The damage caused by worms is difficult to estimate. A few worms cause little apparent harm to a bird and are probably of little significance, but a large number of worms can cause economic losses and even death.

The roundworms (large roundworm, cecal worm and capillaria worm) are elongated, cylindrical and unsegmented. These worms have a well-developed digestive tract and, in contrast to the tapeworm, are either male or female. The body is covered with a tough layer, called cuticle, which prevents the worm from being digested by the chicken's digestive juices.

Large roundworm

The large roundworm, *Ascaridia galli*, is probably the most common internal parasite of the chicken. Most poultrymen are familiar with it and can readily recognize it. It is this worm which is occasionally found in an egg, having wandered up the oviduct from its normal location in the intestines and subsequently being incorporated in the descending egg. The roundworm is white, 1½ to 4 inches long, and lives in the upper small intestine.

General unthriftiness, variable appetite, emaciation, poor growth, weakness, diarrhea, and increased mortality are common symptoms seen in young birds with a large number of worms. Loss in body weight and lowered egg production are also seen in laying birds with a large number of worms.

If a large number of worms are found in the intestines, it is common for the intestines to be irritated, inflamed and thickened.

Cecal worm

The cecal worm, *Heterakis gallinae*, is another very common internal parasite of the chicken. This worm and its eggs are carriers of the blackhead organism, which is spread primarily by the ingestion of infective cecal worm eggs.

The cecal worm is grayish white, 1/3 to 1/2 inch long, and lives in the upper end of the cecal tubes. Some unthriftiness may be seen in birds with a severe infestation. However, few, if any, sumptoms are seen in most birds with cecal worms.

Capillaria worm

An increasingly important intestinal parasite is the capillaria worm, or hairworm. There are several species of capillaria worms. The intestinal capillaria, *Capillaria obsignata*, is the most important and the most damaging. They live in the lining of the upper small intestine. They are colorless, 1/2 to 3/4 inch long, and exceedingly fine. A microscopic examination of scrapings of the intestinal lining is usually necessary for a positive diagnosis.

Severely infested birds have ruffled feathers and diarrhea and appear pale. Weakness, listlessness, and loss of weight are also common symptoms. The intestinal lining is reddened, irritated, inflamed, and thickened. Laying birds have lowered egg production.

Tapeworm

Tapeworms are flattened, ribbon-shaped, usually segmented worms. The tapeworm has no mouth or digestive system (the food being absorbed through the body surface). A tapeworm contains both male and female sex organs within the segments that form behind the head. Tapeworms vary greatly in size. Most tapeworms are 6 to 10 inches long and easily seen. However, some common species are so small that they can be easily overlooked in postmortem examinations unless scrapings of the upper intestinal lining are examined under the microscope.

So far as is known, all tapeworms of the chicken require an intermediate host for completion of their life cycles, the type of intermediate host depending upon the species of worm. The common intermediate hosts include various insects, earthworms, slugs, and snails. The chicken becomes infested by eating the infective intermediate host.

Tapeworms attach themselves to the lining of the upper intestine by means of suction cups and hooklike structures in the head. The roundworm, cecal worm, and capillaria worm do not attach themselves to the intestinal lining but live free in the intestine.

The most common tapeworms are Raillietina cesticillus, Choanotaenia infundibulum, and Davainae proglottina.

Like most internal parasites, tapeworms produce the most severe damage to young birds. Birds severely infested with tapeworms have general symptoms of disease. Unthriftiness, droopiness, ruffled feathers, diarrhea, poor weight gains, weakness and paleness are the typical signs seen.

A few tapeworms may produce little or no disease lesions in the intestines. In heavy tapeworm infestations, a severe enteritis is a common finding. One species of tapeworm causes the formation of nodules in the intestinal wall.

Although there are other species of worms, they are rarely found and generally are of little economic importance.

Prevention and control

Certain sanitation and management practices are essential as an aid in the prevention and control of internal parasites. Among these are proper selection, management and rotation of ranges, proper management of litter, thorough cleaning and disinfection of the premises between groups of birds, strict separation of young birds from old birds, control of free-flying birds, and control of insects and other forms of life that may serve as intermediate hosts.

Although treatment will rid the bird of most of its worms, it will become reinfested if sanitation, hygiene, and good management measures are not employed. Proper diet is equally important. Poultry should receive a diet adequate especially in vitamin A and in the vitamin B complex. Lack of these vitamins makes poultry more susceptible to worm infestations.

Treatment of worms has two advantages. First, it eliminates large numbers of worms from severely infested birds, thus, providing immediate benefits. Second, it reduces the number of eggs that seed and contaminate the litter or range.

Specific drugs are required for each type of worm. Although one worm treatment will eliminate most of the worms, a followup treatment 3 to 4 weeks later is strongly recommended.

Piperazine is the drug of choice if large roundworms are a problem in the flock. If a mixed infestation (tape, cecal and roundworm) is the problem, phenothiazine is effective against cecal worms at the rate of 1 pound per 100 pounds of mash. This is sufficient to treat 700 chickens.

There is no commercially available drug that will effectively eliminate capillaria worms. A heavily infested flock often shows marked improvement if given additional vitamin A. The usual recommendation is to supply a total of 10,000 to 12,000 I.U. vitamin A per pound of feed. This is given 3 weeks out of 4 in a month and the treatment can be repeated.

MANAGING CHICKENS IN HOT WEATHER

Heat stress

Most living animals are better adapted for keeping warm than for keeping cool. The chicken, for all its jungle ancestry, is the same. The body temperature of a hen is about 106.5 F. She keeps that temperature by converting feed energy into heat. The less heat she needs, the less feed energy she uses. To get rid of surplus heat, chickens pant. Some heat is also lost from the body surfaces but, without any sweat glands, the amount is not significant.

The effect of reduced feed consumption, combined with the direct influence of heat on the metabolism of the chicken, produces: first, a drop in production and efficiency as heat rises; second, heat stress; third, prostration; and finally, death. When temperatures first climb to 80 F to 85 F, the birds will decrease their feed intake and drink more (if relative humidity is low). With no further increase in temperature, water consumption will return to normal in a short time. At these temperatures, the layer may produce slightly smaller eggs, but maximum feed efficiency in commercial egg layers as well as in broilers seems to occur in the 80 F to 85 F range. Meat breeders, on the other hand, have their peak in feed-to-egg conversion at lower temperatures.

Temperatures over 85 F cause a rapid deterioration of body functions. Lower feed consumption alone does not explain the results that occur: poor shell quality, reduced or no egg production, heat prostration and death.

Birds will become acclimatized after a while. Experiments have shown that the body temperature of layers returns to normal or stabilizes at a slightly higher temperature 3 to 5 days after exposure to constant high temperatures. With practice, a hen can survive an ambient temperature 5 F higher than before acclimatization.

The higher the relative humidity of the air, the less heat the adult birds can tolerate, but high humidity does not seem to affect growth rate of young chickens.

White Leghorns appear to have greater heat tolerance than other breeds. Thin birds fare better than fat ones. In a heat wave, it is often the biggest broilers of the flock that are lost. Nonproducers are better off than layers, and males better off than females. Birds that have been dubbed (combs removed) will suffer more from heat prostration than those that have their combs and wattles intact.

The following will give you an idea of the effects of different temperatures.

Approximately 55 F to 70 F ---------- Ideal temperature range.

70 F to 85 F ----------------------- Feed consumption is slightly reduced, but so long as intake of essential ingredients is maintained, production efficiency can be good. Egg size is slightly smaller and shell quality reduced.

85 F to 90 F ----------------------- Egg production is lower. Egg size and shell quality deteriorate. Feed consumption falls off.

90 F to 95 F ----------------------- Still lower feed consumption. There is some danger of heat prostration among layers, especially the heavier birds and those in full production, but nonlayers and broilers are not so severely affected. At this temperature, cooling procedures must be in force.

95 F to 100 F ---------------------- Heat prostration is likely. Some emergency measures may need to be taken. Egg production and feed consumption are severely reduced. Water consumption is very high,

depending on relative humidity.

100 F + ---------------------------- Use emergency measures to cool the flock. You are concerned now with survival, not production.

Normally, birds drink about 2 to 2½ times as much as they eat (by weight). As temperatures rise, they will increase water consumption as feed consumption falls off. At 100 F, water consumption may climb to 4 times that at the 70 F level (if relative humidity is very low).

Plan to avoid the heat

If possible, build on a hilltop. Place open-sided buildings to run east-west so that the sun never shines directly into the house. Use wide overhangs at the eaves and solid end walls. The roof angle will reflect away more heat at the hottest time of the day if the face of the slope is not directly toward the sun.

Plant grass or similar ground cover for at least 20 feet around each building to reduce glare. Shade trees may also be beneficial, but beware of any interruption of air movement into the house. Leave at least 100 feet of space between buildings to permit air drainage.

Cooling devices

Evaporative coolers: These are effective only where the building can be closed in. In this respect, open-sided buildings are not so easy to cool as closed ones.

Foggers: Much the same remarks apply here. Because of their tendency to wet the litter, these are more practical in cage buildings and where atmospheric humidity is low.

Roof sprinklers: Where water supply is generous, this method has been effectively used for cooling buildings. It is possibly less effective in terms of the amount of water used than some other methods of cooling.

Air movement: Fans that will turn to blow directly onto the birds are an advantage in any type of housing when the flock is to be cooled. Fans that can cause some air turbulence in the pen, combined with slatted floors that give a free air flow above and below the flock, can do much to keep the birds comfortable. In areas of very high humidity, fans operating in open-sided housing still offer one of the best ways to keep the birds cool. Even in controlled environment houses where the normal fans are not sufficient to produce discernible drafts, circulator fans can produce relief for the birds, as evaporative cooling systems lose efficiency with clinging humidity.

Heat stress prevention measures

1. Before it gets hot, spare drinkers should be handy by each house. At the first sign of hot weather, act quickly to bring relief to the birds. After a few days of high temperatures, they will be accustomed to the new conditions and will not need help much below approximately 90 F.

2. Reduce litter depth to not more than 2 inches.

3. For birds on litter or slats, double the number of drinkers. Use simple pans, 5 to 7 inches deep, and fill them with a hose if necessary.

4. Direct fans to blow onto birds whenever humidity is too high to allow foggers or evaporative coolers to work effectively.

5. Keep the water cool. Water supply pipes should be buried deep enough in the ground so they are not affected by the sun's heat.

6. A supplementary vitamin pack given in drinking water does a lot to maintain flock vitality.

7. Switch on lights in the early morning (for example at 2 o'clock) so that the birds can feed while the air is cooler. Do not forget that, once day length has been extended like this, it can never again be reduced for laying birds.

8. If all else fails and birds are collapsing from the heat, use a hose as an emergency measure to wet the birds' backs. Dip collapsed birds in pails of cold water.

9. If equipment is not available and the situation is critical, for example in a broiler flock in which heat prostration losses are occurring, use some of the feed troughs as temporary water troughs.

10. Reduce your summer heat problems ahead of time by not letting your layers become overly fat. Thin birds can stand more heat than fat ones.

11. The hotter the weather, the more frequently eggs should be collected.

12. Check fan belts and pulleys for wear. Clean fan blades. Anything that reduces the revolutions of the fan can seriously reduce the quantity of air that it can move. Do the same for equipment used in other cooling systems.

EGGS FOR HOME USE OR MARKETING

The care and handling of eggs after they are laid is a very important part of poultry farming, whether the eggs are to be used for home consumption or sold in the markets. Eggs for consumption should be of the highest quality. The production of high-quality eggs depends on three major factors--breeding, feeding (nutrition) and management.

Shell color and thickness, egg size, quantity of thick white, quantity of eggs produced, and to a certain extent, blood spots are hereditary factors that can be bred into the egg-laying flock. The baby chicks or pullets for the initial flock or the flock replacement should, therefore, be obtained from a source that can assure you that these factors have been carefully considered in the breeding program (if you plan to do your own breeding).

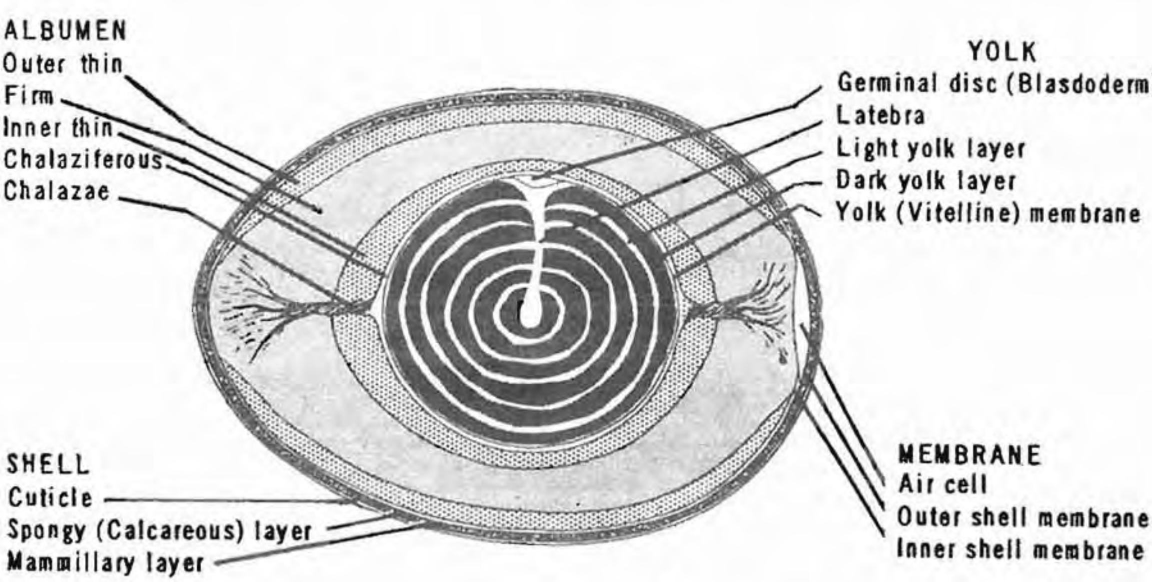
The nutrition of the layers is also important for producing quality eggs. The breaking strength of an egg (shell) is affected by the hen's food, breeding, age, freedom from disease and by hot weather. Feed that is supplemented with a mineral source usually contains sufficient calcium, phosphorus, manganese, and vitamin D to produce sound shells. The source of shell trouble, therefore, is more frequently found in some of the other factors mentioned earlier.

The color of the yolk is also influenced by feeds. Rations high in yellow grains and green feeds produce dark yellow to orange yolks. Rations high in green grasses and cotton seed meal (gossypol not removed) will cause the yolks to acquire a reddish or an olive color.

To be of top quality, eggs must have a high percentage of thick white. A lack of this characteristic can be attributed to breeding, age of the layer, diseases, and to improper care of the eggs after they are laid.

<u>Components of the egg</u>

The normal chicken egg is made up of the components shown in the diagram below. The hen produces an egg that is normally germ free. However, defects or foreign materials can be found in the egg, such as meat spots and blood



The parts of an egg.

spots. The egg could even contain roundworms. The hen may lay eggs with thin shells or no shell or eggs with cracked shells. These defects are sometimes impossible to detect without the aid of a candler or unless the egg is broken out.

Care of eggs after they are laid

Immediately after the egg is laid, it begins to lose quality even if it is removed from the nest, cooled, packed, and marketed promptly. There is nothing you can do to improve quality once the egg is laid, but you can retard loss of quality by proper care and handling.

Keep temperature and humidity conditions at optimum levels. It is important to gather eggs at least 3 times daily: at midmorning, at noon, and again during the later afternoon. Use a clean receptacle that has ventilated sides and bottom (Figures 33 and 34). Place the eggs immediately in a cool, humid storage room or a homemade egg cooler (Figure 35). Depending on the area, storage temperature within the range of 40 F to 60 F, and relative humidity at approximately 78 to 80 percent will aid in preserving interior quality.

Figure 32. Collecting eggs from the nest in a tin can. To keep breakage to a minimum, do not use a solid container such as this.

Figure 33. A wire basket for gathering eggs causes less breakage than the can shown in Figure 32.

Figure 34. Plastic-coated wire baskets on a three-wheeled cart is the type preferred. Using a cart, you can also gather eggs on 30-egg flats.

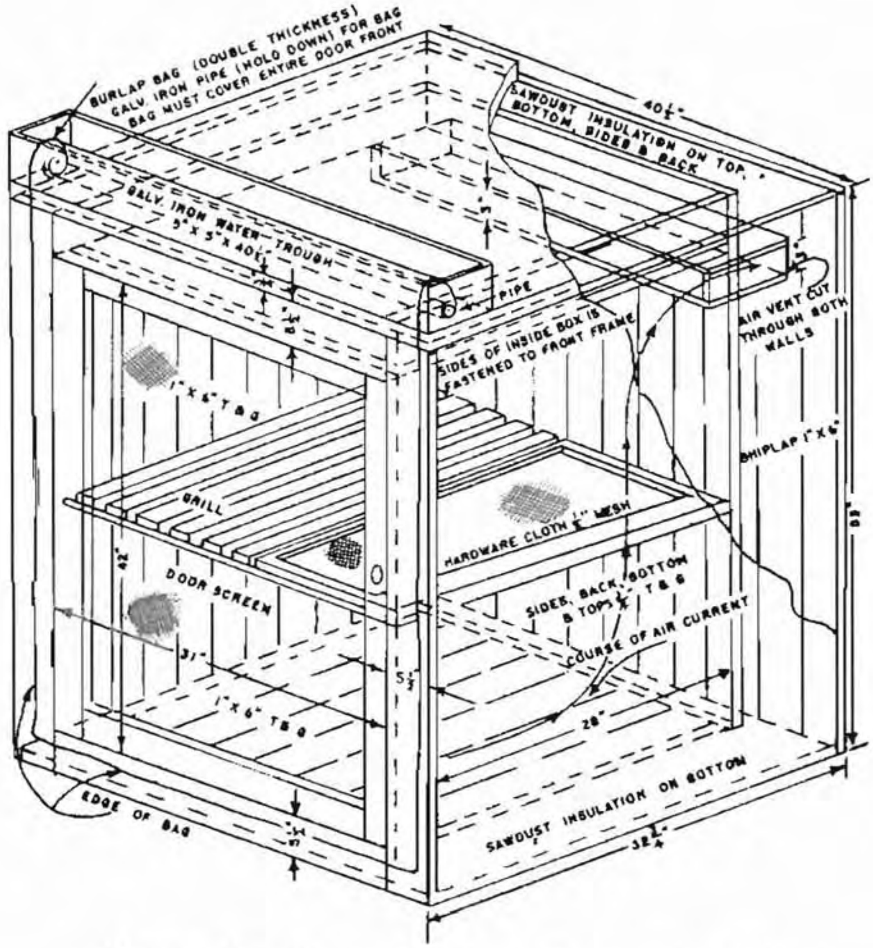


Figure 35. Homemade egg cooler. Not drawn to scale.

List of materials

Outside box: Rough shiplap 1" x 6"
6 pcs. 1" x 6" - 10' sides and back
6 pcs. 1" x 6" - 8' top and bottom
1 pc. 1" x 3" - 14' door
1 pc. 1" x 6" - 16' front frame
Inside box: T&G 1" x 6" SIS
5 pcs. 1" x 6" - 14' sides, top and bottom
1 pc. 1" x 2" - 16' S4S tray
2 pcs. 1" x 2" - 8' S4S middle frames
1 pc. 3-ply 12" x 26" air vent
Hardware cloth 30" x 70"
4 pcs. 1" x 3" - 10' S4S box frames
Inside box is built of 1" x 6" T&G

Cut vent in back 3-5/8" x 5½" x 28"
Use 3-ply 5/16" for vent
Screen back side of vent
Outside box is built of rough 1" x 6" shiplap
Front is (built up) frame
Screen door fits inside frame
1 pair 4" strap hinges
1 small door catch
1 heavy burlap curtain (double thickness) 40½" x 62"
1 pc. galvanized iron pipe 40" long

Candling eggs

All eggs, including those to be used at home, should be candled for interior quality. The eggs can be candled either before or after cooling, depending on your work schedule. Candling should be planned so that all of the eggs can be handled in one continuous operation.

What is candling? It is a method by which you are able to "see" the inside of an egg without breaking it. You do this with a candler, which is simply a lightproof box with a source of strong light within it. You can build a five-sided box (open bottom) with cardboard, wood, or metal, with an opening of about 1 inch in diameter on the forward side and a similar opening on top. As a source of light, you can use either a lantern, a gas lamp, or an electric bulb. Or you can buy a candler such as that shown in Figure 36.

The first thing to look for is any break in the shell. If you find a break, separate the egg from the ones without any breaks. Eggs with breaks in the shell can be eaten, but they should not be stored for long periods (even in the refrigerator) because they are more "susceptible" to bacterial contamination than eggs with sound shells. They should be eaten immediately.

Figure 36. Candling eggs with a commercial candler. The operation should be done in a semi-dark room for better accuracy.

Looking at the blunt end next, you should be able to see the air cell. The air cell normally forms at the blunt end because this part of the egg-shell has more pores than other parts. It is formed right after the egg is laid, when water from within the egg is lost and the two shell membranes part to fill the void created from the loss of moisture. Because of some malformation in the eggshell, however, the air cell may form in areas other than at the blunt end. Figure 37 shows the quality of eggs as related to air-cell depth.

While checking the shell and the air cell, you should also look for shell texture, shape, and cleanliness (in countries where marketing regulations are in effect). The shell should be strong, have a smooth texture, and be free from irregularities. The shape of the egg should be ovate (Figure 37).

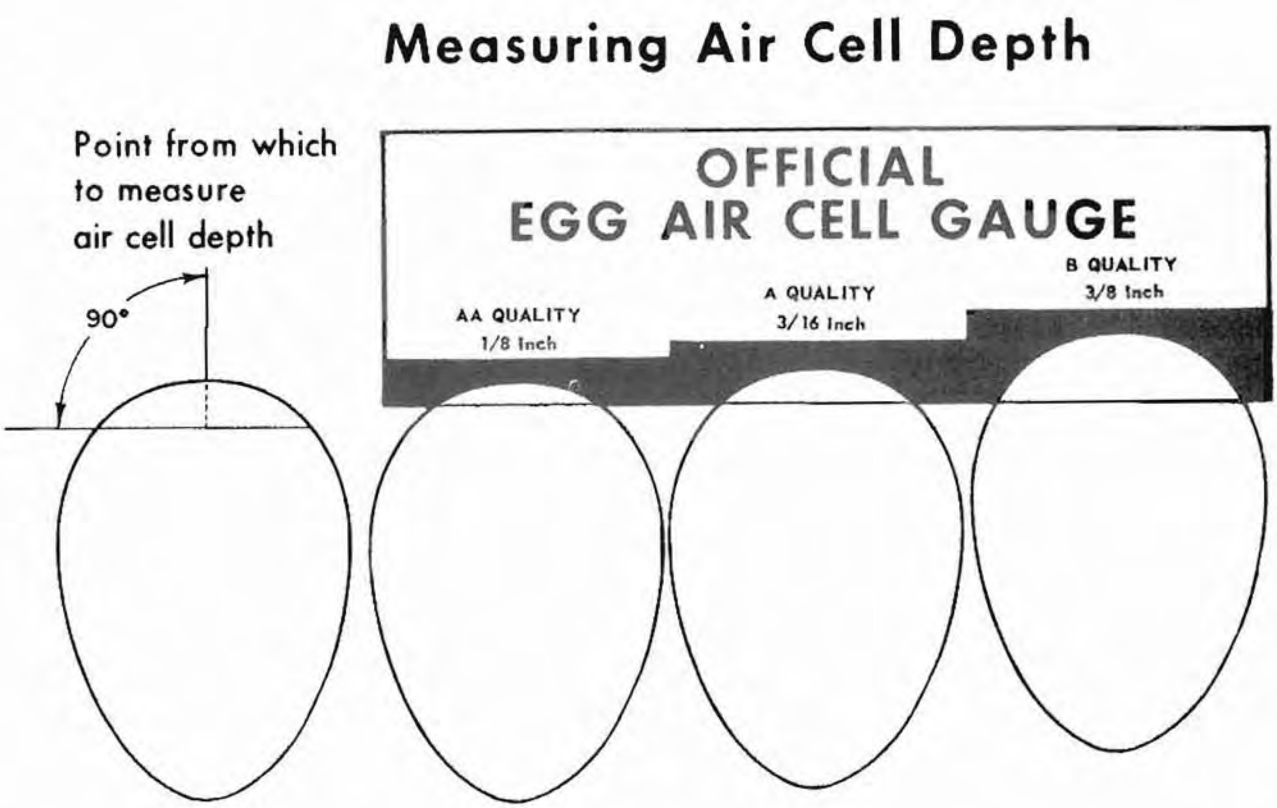


Figure 37. Egg quality as measured by air-cell depth. The rectangular "gauge" may be cut out, pasted on a hard cardboard of similar size, and be used when determining different grades of eggs.

After checking these qualities, turn the egg while it is against the opening of the candler. Note the shadow cast by the yolk. The yolk should be visible only as a slight shadow in a good quality egg, and it should have limited freedom of motion. When doing this, you are actually testing the firmness of the albumen; the darker the yolk shadow, the more watery is the albumen, which indicates a low quality egg. Also, when you turn the egg, watch for any red (or black) discoloration in the albumen. This discoloration means that there is some blood or a bit of tissue in the albumen. Any egg with red or black discolorations should be removed and separated from those without them. Very often the red discoloration will be found on the surface of the vitelline or yolk membrane. These, however, are rather difficult to detect unless they are quite large.

In the United States, there are both Federal and State government laws regulating egg marketing and standards for egg quality (Tables 11, 12). Since these are not yet in effect in many of the countries in the Pacific, discussion on these will be omitted. For further information, refer to the "United States Standards for Quality of Individual Shell Eggs" (chart). It can be obtained by writing:

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20250

Cleaning dirty eggs

Approximately 90 percent of the eggs are clean when first laid. It is only after they are laid that foreign materials, such as fecal matter, nesting or litter material, adhere to the shell. Keep in mind that all of these materials contain bacteria that can contaminate the contents of the egg. It is therefore essential that clean nesting material is constantly provided.

No matter how efficient the farm management and how careful the handling, there is always a small percentage of dirty eggs produced. Here, "dirty eggs" refers to those eggs with foreign material adhering to the shell surface. Because these eggs are covered with bacteria, it is very important that they be cleaned effectively to prevent bacterial penetration. Cleaning should be done after all of the eggs are candled.

There are two methods of cleaning eggs--dry cleaning and wet washing. Dry cleaning can be done on the dirty areas of the shell with a dry abrasive such as emery cloth or fine sandpaper mounted on a shoe buffer (Figure 38). Be sure to clean only those eggs that are moderately or slightly dirty or stained. Do not attempt to clean extremely dirty eggs because they cannot be cleaned well enough with this dry method.

Wet washing is very effective in cleaning all degrees of dirtiness on eggshells. But wet washing must be done properly, since wetting a dirty shell provides moisture in which bacteria can multiply rapidly and this may help the bacteria to enter the egg. When using the washing method, the following precautions should be kept in mind:

1. Wash eggs with water that is warmer than the contents of the eggs. A washing solution that is colder than the egg causes the egg contents to contract and thus allows the washing solution (with bacteria) to be drawn into the egg through the shell pores.

Figure 38. Hand buffing to clean market eggs.

2. Select a detergent-sanitizer (detergent for cleaning and sanitizer for killing bacteria) that is compatible with the wash water. Certain degrees of hardness of water cause unfavorable reactions with different quarternary ammonium compounds. The detergent-sanitizer should be one that will retain its sanitizing ability longer than its washing power.

3. The detergent should be one that will not give off foreign odors that may be imparted to the egg.

4. Keep wash water as clean as possible.

5. Rinse by spraying or in running water that is slightly warmer than the wash water.

6. Dry the eggs thoroughly and quickly. Mechanical washers have fan-

driven dryers attached to them (Figure 39).

If you have no mechanical washer and want to use the washing method of cleaning, the simplest method is to use a container of warm water (about 110 F) with the recommended amount of detergent-sanitizer dissolved in it. Dip a clean cloth in this solution and "wash" the dirty eggs with it. Rinse as above and dry the eggs as quickly as possible. Be sure to always use a clean washing solution and clean rinsing water.

Storing eggs

As noted earlier, all eggs with cracked shells should be eaten as soon as possible. All eggs with blood or meat spots should be discarded unless the spots are very small, in which case you could cook these and feed them to your household pets.

Eggs that have no defects (those intended for home use or marketing) should be stored under conditions of temperature and humidity mentioned earlier until they are used or marketed. This will insure the consumer of high-quality eggs. Do not store eggs together with other foods that have strong and pungent odors, such as garlic and onion, because the eggs will absorb the odor given off by these foods.

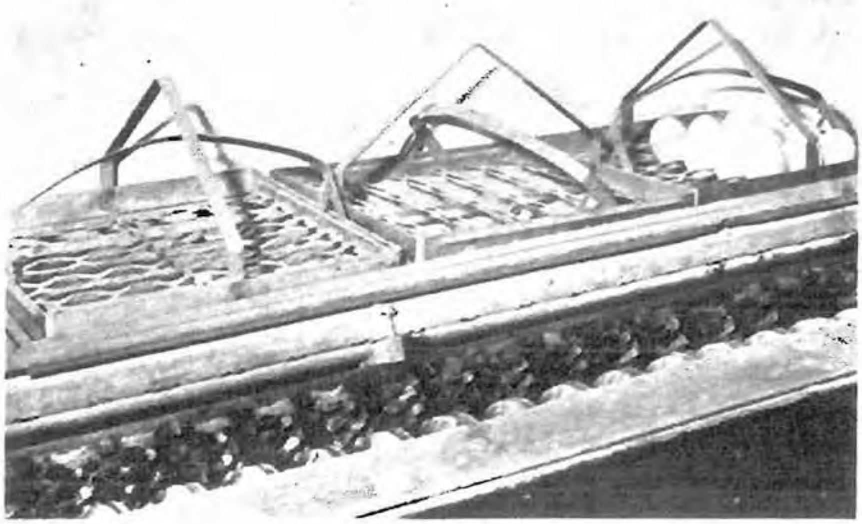


Figure 39. A simple type of egg washer with a fan-driven dryer attached.

TABLE 11. Summary of United States standards for quality of individual shell eggs

	Specifications for each quality factor			
Quality factor	AA quality	A quality	B quality	C quality
Shell	Clean. Unbroken. Practically normal.	Clean. Unbroken. Practically normal.	Clean, to very slightly stained. Unbroken. May be slightly abnormal.	Clean, to moderately stained. Unbroken. May be abnormal.
Air cell	1/8 inch or less in depth. Practically regular.	3/16 inch or less in depth. Practically regular.	3/8 inch or less in depth. May be free or bubbly.	May be over 3/8 inch in depth. May be free or bubbly.
White	Clear. Firm. (72 Haugh units or higher.)	Clear. May be reasonably firm. (60 to 72 Haugh units.)	Clear. May be slightly weak. (31 to 60 Haugh units.)	May be weak and watery. Small blood clots or spots may be present.* (less than 31 Haugh units.)
Yolk	Outline slightly defined. Practically free from defects.	Outline may be fairly well defined. Practically free from defects.	Outline may be well defined. May be slightly enlarged and flattened. May show definite but not serious defects.	Outline may be plainly visible. May be enlarged and flattened. May show clearly visible germ development but no blood. May show other serious defects.

*If they are small (aggregating not more than 1/8 inch in diameter)

TABLE 12. U.S. weight classes for consumer grades for shell grades

Size or weight	Minimum net weight per dozen (ounces)	Minimum weight for individual eggs at rate per dozen (ounces)	Minimum net weight per 30 dozen (pounds)
Jumbo	30	29	56
Extra large	27	26	50½
Large	24	23	45
Medium	21	20	39½
Small	18	17	34
Peewee	15	15	28

Diagnosing egg quality problems

The following is a summary of some of the egg quality problems you might encounter from time to time, and the probable causes of these problems.

I. Shell problems

A. Odd-shaped eggs

1. Heredity (primary cause)
2. First-laid eggs
3. More frequent with older birds
4. Newcastle disease
5. Infectious bronchitis disease

B. Thin, porous, or soft-shelled eggs

1. Age of birds (older birds produce thinner shells)
2. Temperature above 70 F to 90 F
3. Heredity
4. Insufficient calcium, phosphorus, manganese and vitamin D
5. Excess phosphorus
6. Fright (particularly during the dark hours)
7. Newcastle disease
8. Infectious bronchitis disease

C. Rough or abnormal shell texture

1. Heredity
2. Excessive calcium
3. Extended use of high levels of antibiotics or sulfa drugs

4. Newcastle disease
5. Infectious bronchitis disease

D. Mottled shells

1. Primarily relationship between temperature and relative humidity (incidence is increased by high or low extremes in humidity, porous shells, in spring weather)
2. Heredity

E. Tinted shells from white-egg layers

1. Heredity (primary cause)

F. Yellowish colored white shells

1. Excessive levels of antibiotics
2. Pigment-producing pseudomonas organism

G. Tremulous or loose air cells

1. Rough handling (primary cause)
2. Length of storage (incidence increases with time)
3. Newcastle disease
4. Infectious bronchitis disease

H. Pink membranes

1. Heredity (primary cause)

II. Albumen problems

A. Increased thin white

1. High temperatures
2. Improper storage and handling
3. Length of lay (eggs from older birds have more thin white)
4. Heredity
5. High levels of ammonia fumes
6. Newcastle disease
7. Infectious bronchitis disease

B. Greenish albumen (fresh eggs)

1. Too much riboflavin (vitamin B_2) in feed

C. Cloudy white

1. High carbon dioxide level in extremely fresh eggs (prolonged by early oiling)

D. Pink white

1. Gossypol in cottonseed products

E. Bloody white

1. Heredity
2. Hemorrhage in oviduct

F. Meat spots

1. Heredity
2. Bits of pigment from oviduct
3. Oxidized blood spots

III. Yolk problems

A. Blood spots

1. Heredity (primary cause)
2. Vitamin A deficiency increases incidence
3. High temperature increases incidence
4. Age of bird (percentage is increased as birds get older)
5. Deficiency in vitamin K (rarely seen)
6. Severe fright (occasional cause)

B. Dark yolks

1. Pigment content of diet

C. Platinum (white) yolks

1. Unidentified microorganism

D. Brownish-green yolks

1. Gossypol
2. Piperazine citrate (wormer)

E. Mottled yolks

1. Anti-oxidants (such as gallic acid, n-propyl gallate, and tannic acid)
2. Gossypol
3. Ammonia fumes
4. Dibutyltin dilaurate (wormer)
5. Nicarbazin (rare)
6. Too lengthy holding time (aggravating influence)

F. Weak yolk membrane (vitelline membrane)

1. Too high holding temperature
2. Too long holding time
3. Too low pH of egg

G. Large chalazae

1. Heredity (primary cause)

Composition of the egg

The physical and chemical compositions of the chicken egg are shown in Tables 13 and 14.

TABLE 13. Chemical composition of a chicken egg

Component	White or albumen %	Yolk %	Whole egg %
Water	87.8	49.0	65.5
Protein	10.0	16.7	11.9
Fat	0.05	31.6	9.3
Ash	0.8	1.5	0.9
Carbohydrate	0.5	--	--
Shell	--	--	11.2

TABLE 14. Physical composition of a chicken egg

Component	Percent of egg (range)	Percent of egg (average)
Shell	8.7 - 13.9	11.0
Edible contents	86.1 - 91.3	89.0
Albumen	47.8 - 63.7	57.1
Yolk	27.6 - 40.0	31.9

PROCESSING POULTRY

In the United States, the predominant "type" of chicken used for meat is the broiler or the fryer. In Asian countries bordering the Pacific and also in the Pacific islands, older birds are preferred.

Commercially, chickens in the United States are classed according to the following United States Department of Agriculture specifications:

Rock Cornish game hen or Cornish game hen - A Rock Cornish game hen or Cornish game hen is a young chicken (usually 5 to 7 weeks of age) weighing not more than 2 pounds ready-to-cook. It is a Cornish chicken or the progeny of a Cornish chicken crossed with another breed of chicken.

Broiler or fryer - A broiler or fryer is a young chicken (usually 9 to 12 weeks of age), of either sex, that is tender-meated with soft, pliable, smooth-textured skin and flexible breastbone cartilage.

Roaster - A roaster is a young chicken (usually 3 to 5 months of age), of either sex, that is tender-meated with soft, pliable, smooth-textured skin and breastbone cartilage that may be somewhat less flexible than that of a broiler or a fryer.

Capon - A capon is a surgically unsexed male chicken (usually under 8 months of age) that is tender-meated with soft, pliable, smooth-textured skin.

Stag - A stag is a male chicken (usually under 10 months of age) with coarse skin, somewhat toughened and darkened flesh, and considerable hardening of the breastbone cartilage. Stags show a condition of fleshing and a degree of maturity intermediate between that of a roaster and a cock or rooster.

Hen or stewing chicken or fowl - A hen or stewing chicken or fowl is a mature female chicken (usually more than 10 months of age) with meat less tender than that of a roaster and nonflexible breastbone tip.

Cock or rooster - A cock or rooster is a mature male chicken with coarse skin, toughened and darkened meat, and hardened breastbone tip.

No matter what class of chicken you are accustomed to eating, it is important that you process the bird properly and store the carcass under favorable conditions. Unlike beef or pork, chicken meat deteriorates very rapidly if kept at room temperature, even for a short time. Even with refrigeration, the storage period should not be for more than 3 or 4 days. If a long storage period is necessary, the processed carcass must be frozen.

Some points to keep in mind when slaughtering and processing chickens are:

1. Killing - Chickens should be starved before slaughtering; that is, you should remove the feed from these birds for about 3 to 4 hours. This will make cleaning easier because the crop will be empty and the gizzard will be empty or nearly so.

   One of the best methods of slaughtering is to cut the jugular vein located on the lateral side of the neck. Another method is "debraining," by using a slender-bladed knife to stick the brain through the cleft in the upper palate and then to cut across to induce bleeding. This method is used primarily when "dry picking" of the feathers is desired. Regardless of the method used, the important thing is to induce good bleeding. Poor bleeding is a direct cause of poor keeping quality, the development of undesirable flavors, and an unappetizing appearance of the carcass.

2. Scalding - This is the process whereby the slaughtered chicken is immersed in hot water so the feathers may be removed easily. Broilers and fryers should be scalded in water heated to a temperature of about 128 F to 130 F; older chickens (stewers and cocks) should be scalded in water heated to a temperature of about 155 F to 160 F.

Scalding should be done in about 1½ minutes. Hold the feet of the bird and agitate it in the water with an up-and-down motion. After about a minute, try pulling the main tail and flight feathers (singly). If they are removed easily, the bird is properly scalded. You should then remove all of the feathers as quickly as possible, starting with the flight and the tail feathers.

3. Processing - As soon as the feathers are removed, eviscerate (remove the internal organs) and remove the head and feet in the manner to which you are accustomed. If you have to delay this operation, immerse the carcass in clean, cold or ice (where available) water. This is to make sure that "spoilage" does not set in quickly. Unless the carcass is to be cooked within a short time, it should be chilled immediately after processing.

When chickens are raised in nonconfinement, it is difficult to keep records on their hatch dates, and you will not be able to determine the exact ages of your birds. Because the age of the birds determines how you prepare them for eating (old birds should not be broiled or fried because the meat will be tough), you will want to know the approximate age of the birds you plan to slaughter. The table on the following page is presented to make the task of determining age easier. Included also is information on ducks and geese.

These are but a few points in processing poultry meat. The important thing is that the job must be done properly because the meat is for human consumption, and the health of the consumer is at stake.

For further information on the subject, see the articles in the list of references.

	Young birds	Mature birds
Comb Chickens	Pliable, resilient, not wrinkled, points sharp.	Wrinkled, coarser, thicker points rounded.
Bill Ducks	Pliable - not completely hardened.	Hardened.
Plumage	Fresh, glossy appearance.	Faded, worn except in birds that have recently molted.
Fat	Smooth layers with brighter color. Not lumpy over feather tracts.	Generally darker in color, inclined to lumpiness over heavy feather tracts.
Breastbone	Cartilage, if present, pliable and soft.	End of keel--hardened cartilage, bony.
Pinbones	Pliable.	Not pliable.
Shanks	Scales on shanks, smooth, small.	Scales, larger, rough, and slightly raised.
Oil sac	Small, soft.	Enlarged, often hardened.
Spurs (male chickens, turkeys, occasionally adult females).	Small, undeveloped, cornlike.	Spurs gradually increase in length with age, becoming somewhat curved and sharper. Hens often have fine, sharp spurs after first year.
Windpipe Ducks, Geese	Easily dented.	Hardened, almost bony to the touch.
Flesh	Tender meated, translucent appearance. Fine texture.	Coarser texture, darker, hardened muscle fibers.
Drumsticks	Lacking in development, muscles easily dented.	Generally rounded, full, firm.

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APPENDIX A

ANALYSIS OF FEEDSTUFFS*

Feedstuff	Energy	Protein		Amino acids				Mineral		Analysis		
Energy concentrate	M.E. kcal/lb	Crude %	Dig. %	Lys. %	Meth. %	Cys. %	Tryp. %	Ca. %	P. %	E.E. %	Fib. %	D.M. %
Barley (all an.)	1280	11.6	10.0	.6	.18	.18	.20	.09	.47	1.9	5.0	89
Barley (Pac. coast)	1300	9.0	6.9	.4	.15	.15	.12	.07	.35	1.9	5.0	90
Cassava meal	----	1.4	1.0	--	--	--	--	.13	.15	.6	3.1	86
Citrus pulp (dried)	600	6.6	2.9	.20	.08	.10	.06	1.96	.12	4.6	13.1	90
Copra (pressed)	----	14.0	10.5	--	--	--	--	.15	.45	34.6	8.1	89
Coconut oil meal (solv.)	----	21.4	18.2	.5	.30	--	--	.17	.61	1.8	15.0	91
Corn #2 dent	1580	9.3	7.2	.2	.10	.10	.10	.02	.33	4.3	2.0	88
Corn & cob meal	1290	8.1	5.9	.16	.08	.08	.08	.04	.24	3.2	8.0	87
Fats, oils or tallow	----	0.0	0.0	.0	.0	.0	.0	.00	.00	100.0	.0	100
Garbage (wet)	----	3.0	--	--	--	--	--	.20	.07	5.4	1.0	20
Millet grain	----	12.0	8.6	--	--	--	--	.06	.20	4.1	8.6	90
Milo	1480	11.1	8.6	.30	.10	.20	.10	.04	.33	2.8	2.0	89
Molasses, cane	890	3.2	0.0	.0	.0	.0	.0	.63	.05	.1	.0	75
Oats (all an.)	1190	11.8	8.3	.40	.20	.20	.20	.11	.39	4.5	11.0	89
Oat groats (hulled)	1450	16.7	14.6	.56	.25	.25	.25	.07	.43	5.8	3.0	91
Rice grain	----	8.2	6.0	.30	.20	.10	.10	.05	.26	1.2	2.0	89
Rice bran (unspec.)	----	13.5	9.2	.50	.20	.10	.10	.06	1.82	15.1	11.0	91
Rice polishings	----	11.8	9.0	.50	.20	.10	.10	.03	.14	13.2	3.0	90
Sugar, crude	----	.8	.0	.00	.00	.00	.00	.20	.03	.0	.0	99
Wheat (all an.)	1500	12.7	10.7	.50	.20	.20	.20	.06	.41	1.7	3.0	89
Wheat bran	520	16.0	13.0	.60	.10	.30	.30	.14	1.17	4.1	10.0	89
Wheat millfeed (mixed)	1250	15.3	12.7	.50	.20	.20	.20	.09	1.02	4.0	8.0	90
Whey	----	13.1	11.8	1.10	.20	.30	.20	.87	.79	.8	.0	94

* Abstracted from a table compiled by C. C. Brooks, Department of Animal Sciences, College of Tropical Agriculture, University of Hawaii.

ANALYSIS OF FEEDSTUFFS (continued)

Feedstuff	Energy	Protein		Amino acids				Minerals		Analysis		
Protein concentrate	M.E. %	Crude %	Dig. %	Lys. %	Meth. %	Cys. %	Tryp. %	Ca. %	P. %	E.E. %	Fib. %	D.M. %
Blood meal	1300	80	57	6.90	.90	1.40	1.10	.28	.28	1.6	1.0	91
Brewers dr. grains	1150	23	17	.90	.40	.40	.30	.27	.50	6.2	15.0	92
Corn gluten meal	1500	43	36	.70	1.00	.70	.21	.10	.40	2.2	3.8	91
Cottonseed meal	1100	42	33	1.60	.60	.60	.50	.15	1.10	1.6	11.0	91
Feather meal	1150	85	60	1.50	.52	2.30	.57	.20	.75	2.0	2.0	95
Fish meal (menhaden)	1350	61	50	5.30	1.80	1.00	.60	5.49	2.81	7.7	--	92
Fish meal (tuna)	1160	55	45	4.80	1.47	1.00	.55	5.00	3.00	11.0	--	90
Koa haole seed	----	21	--	1.20	.10	.13	.21	--	--	6.5	11.7	88
Linseed meal (solv.)	640	35	30	1.30	.84	.66	.56	.40	.83	1.7	9.0	91
Meat meal (all an.)	920	53	44	3.40	.80	.66	.61	8.00	4.00	6.0	2.5	94
Meat & bone meal (Hawaii)	900	56	47	3.60	.84	.70	.64	11.00	5.30	9.3	0.5	92
Milk (sk. dr.)	1200	33	30	2.80	.81	.42	.45	1.25	1.00	.5	.0	92
Peanut oil meal	1000	47	42	1.11	.60	.74	.50	.20	.60	1.0	13.0	89
Soybean oil meal (44%)	1020	46	42	2.90	.60	.60	.60	.32	.67	.9	6.0	89
Poultry by-product meal	1050	55	45	3.70	.96	.95	.45	3.00	1.70	12.0	2.5	90
Soybean oil meal (50%)	1150	51	47	3.22	.67	.67	.67	.26	.62	.8	3.0	90
Tankage	1200	60	51	4.00	.80	.66	.70	6.00	3.20	8.1	2.0	92
Urea	0	263	195	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98
Yeast (torula)	----	48	42	3.80	.80	.60	.50	.57	1.68	2.5	2.0	93

ANALYSIS OF FEEDSTUFFS (continued)

Feedstuff	Energy	Protein		Mineral		Analysis			
Roughages	TDN %	Crude %	Dig. %	Ca. %	P. %	E.E. %	Fib. %	Lignin %	D.M. %
Alfalfa (all an.)	50	15.5	11.0	1.64	.26	1.9	28	11	88
Alfalfa (dehydrated)	54	17.1	12.5	1.89	.25	2.2	26	--	90
Bagasse	37	2.3	1.6	.90	--	2.7	37	--	89
Beet pulp (dried)	62	9.1	4.3	.68	.10	.6	19	8	91
Bermudagrass (green)	15	4.2	2.0	.53	.22	.8	10	--	37
Bermudagrass (dry)	44	8.1	4.1	.46	.20	1.8	28	11	90
Guineagrass (green)	12	1.6	.4	.10	.08	.4	10	12	27
Corn silage (high DM)	--	7.7	5.0	.12	.09	--	22	--	38
Corn silage (medium DM)	19.8	2.3	1.3	.09	.07	.9	6.3	--	28.5
Honohono	7.7	1.3	.9	--	--	.3	3.3	--	12
Kikuyugrass	8.6	2.6	1.5	.05	.05	.4	5.5	--	18
Koa haole	17.2	6.1	4.0	.28	.07	.7	12.3	--	33
Napiergrass (green)	12.5	1.0	.5	.07	.12	.5	10	--	27
Napiergrass (hay)	45.4	8.2	3.8	--	--	1.8	34	--	89
Napiergrass (dehydrated)	51.4	17.5	12.3	.60	.08	3.4	20	--	89
Panicum (green)	13.2	2.0	1.3	.05	.06	.5	6.9	--	22
Pangola (green)	16.3	1.3	.9	.20	.07	1.6	11.6	--	26
Pineapple bran	66	4.0	.8	.16	.12	1.5	17.0	--	90
Pine hay	53.1	--	1.5	--	--	--	--	--	--
Pine silage	15.4	1.9	.9	--	--	.3	4.9	--	21
Rhodesgrass (green)	17.6	1.7	1.0	.10	.10	.4	9.7	--	25
Rhodesgrass (hay)	51.4	5.7	2.6	.35	.27	1.3	31.7	--	89
Sudangrass (green)	15.4	1.9	1.3	.09	.10	.4	8.6	--	24
Sudangrass (hay)	48.6	8.8	4.3	.36	.27	1.6	28	--	89
Sugarcane strippings (green)	21.7	1.6	0.0	.04	.12	.5	20.3	--	46
Sugarcane tops (green)	12.8	1.4	.7	.02	.06	.5	8.5	--	23
Sweet potato tops (green)	7.7	2.9	1.9	.09	.04	.4	1.7	--	12

ANALYSIS OF FEEDSTUFFS (continued)

	Mineral	
	Ca. %	P. %
Calcium and phosphorus supplement		
Bone black	27	12.7
Bone meal (steamed)	29	13.6
De. F. phosphate rock	29	13.3
Dicalcium phosphate	29	19.1
Calcium supplement		
Limestone	33.8	
Oystershell	38.0	
Coral rock	38.0	
Phosphorus supplement		
Diammonium phosphate		22.3
Sodium tripolyphosphate		25.3

Magnesium sulfate	9.9% Mg
Manganese oxide	72% Mn
Ferrous carbonate	17% Fe
Calcium iodate	65% I
Cobalt carbonate	50% Co
Copper oxide	80% Cu
Copper sulfate	25% Cu
Zinc oxide	80% Zn
Zinc sulfate	36% Zn
Zinc carbonate	56% Zn

NOTE: As part of a structural reorganization, the Hawaii Cooperative Extension Service and the Hawaii Agricultural Experiment Station have been merged under the new name HAWAII INSTITUTE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES, College of Tropical Agriculture and Human Resources, University of Hawaii.

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